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ATLAS

OF

CLIMATIC TYPES IN THE UNITED STATES

1900–1939

UNITED STATES DEPARTMENT OF AGRICULTURE
1862 1889

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OF
CLIMATIC TYPES IN THE UNITED STATES
1900–1939

By
C. W. THORNTHWAITE
Chief, Climatic and Physiographic Division, Office of Research, Soil Conservation Service

IN COOPERATION WITH
DIVISION OF CLIMATE AND CROP WEATHER
UNITED STATES WEATHER BUREAU

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ATLAS OF CLIMATIC TYPES IN THE UNITED STATES, 1900–1939

By C. W. Thornthwaite, *Chief, Climatic and Physiographic Division, Office of Research, Soil Conservation Service*

INTRODUCTION

Drought is a hazard from which few parts of the United States are entirely free. It is exceptional in the humid East, occurs moderately often in the subhumid Middle West, strikes with discouraging frequency in the semiarid Great Plains, and is chronic in the arid Southwest. Drought entails little or no agricultural risk in humid or arid climates. In the one, unfavorable years are too few to be taken into account, and in the other, favorable years are so unusual that agriculture is not attempted without irrigation. Drought takes its greatest toll in the transitional subhumid and semiarid regions. In the semiarid region the occasional favorable year encourages farming, but unfavorable years come so often that agriculture may be unprofitable or even impossible on a permanent basis.

If coming droughts could be anticipated at planting time, much loss could be avoided. As yet, however, dependable seasonal forecasts cannot be made. Although drought years and flood years cannot be predicted, it is possible by using the many records of the United States Weather Bureau to determine the frequency with which droughts or other climatic events are likely to occur. Such information is of great aid in evaluating the agricultural potentialities of a region. It is essential to effective land use planning and to intelligent evaluation of erosion hazard. It can tell for a particular area whether, over a period of years, agricultural successes can be expected sufficiently often to make continued farming possible. Similar information can be obtained for the grazing regions.

Climatic analysis of actuarial type should form the basis for policy and action in regions of high climatic risk, such as the Great Plains. Evaluation of use capabilities of any area should be based on a climatic index. Edaphic factors at one site may to some extent minimize the climatic hazard; at another, they may actually accentuate it. A detailed soil or land-type survey will determine the edaphic variation of the individual field above or below the use capability imposed on the area by climate. The edaphic effect of different soil types is relatively small as compared with the larger effect of differences of climate over the continent.

The maps in this atlas are restricted to a presentation of the moisture factor of climate and show the normal position of the principal climatic types, their variation in position from year to year, and finally, the frequency of occurrence of the various individual climates. From a study of these maps, an appreciation of the diversity of the problems of soil and water conservation in the different parts of the country may be obtained.

THE EVOLUTION OF THE CLIMATIC PATTERN

The earth rotates on its axis and revolves around the sun in such a manner that a belt near the Equator receives a maximum of heat from the sun and the two polar caps receive a minimum. As a result the air is warmed more in equatorial regions than around the Poles. Difference in temperature results in difference in weight—the cold air being heavier than the warm—and a circulation is established. Cold air flows equatorward along the surface, spreading out in a progressively thinner layer; and warm air, displaced by the cold air in equatorial latitudes, rises and moves poleward aloft, being crowded into smaller space as it proceeds. If there were no complications to this simple pattern of atmospheric circulation, the belt of ascending air along the Equator would be very rainy and the areas of subsiding air around the Poles very dry. The midlatitudes would be areas of transition.

However, the rotation of the earth tends to deflect the air from its original course; to the right, north of the Equator, and to the left, south of it. In consequence, the air from the equatorial region flowing poleward in the upper levels appears as west wind. Similarly, there is a tendency toward the development of east winds along the surface. Friction with the earth's surface, however, prevents the full development of these winds and results instead in a series of belts with prevailing east winds in the polar regions and near the Equator but with west winds in the middle latitudes. The simple equatorward drift of air in the lower levels and poleward drift aloft is broken down into a series of cells with air ascending in the equatorial region and in high middle latitudes, and descending in the Tropics and in polar regions. This cellular pattern of atmospheric circulation is shown by the arrows in figure 1, *A*.

If we picture an earth that rotates on its axis and revolves around the sun, as our earth does, but possesses a surface consisting entirely of water or lacking in large water bodies altogether, the climatic zones would conform with the belts of prevailing winds. Rainy belts would occur at the Equator and in high middle latitudes; dry belts, in low middle latitudes and in polar regions. This climatic pattern is shown on figure 1, *A*; the areas receiving more than 20 inches of precipitation annually being shaded, and those receiving less, unshaded.

This zonal arrangement of rainfall belts is highly schematic and more or less hypothetical; the 20-inch rainfall figure would apply only under a specific combination of environmental conditions. If the surface consisted entirely of water, moisture for evaporation and later precipitation would be available everywhere and the rainy belts would presumably be wider and the dry belts narrower than indicated. On the other hand, if the earth's surface consisted entirely of land, with only small, scattered lakes providing moisture for evaporation, the rainy belts would be narrower and the dry belts wider than shown.

It is difficult to represent clearly all features of the climatic pattern of the earth on any flat map or diagram. It can be adequately depicted only on a globe. To approximate this as closely as possible, the climatic pattern is presented twice in figure 1; once, looking down on the Equator, and again, looking down on the North Pole. Figure 1, *B*, is, therefore, a polar view of the same distribution as shown in figure 1, *A*.

The existence of great ocean bodies, covering more than three-fourths of the earth's surface and oriented chiefly in a north-south direction, permits the development of ocean currents. Water heated in the equatorial region flows to high latitudes and is replaced by cold water moving toward the Equator, and results in a corresponding warming of the polar regions and cooling of the equatorial belt. The rates of heating and cooling of land masses differ from those of great water bodies, and consequently temperature anomalies between continents and oceans develop, with lands in general warmer in summer and colder in winter than the oceans in comparable latitudes.

Temperature gradients set up as a result of unequal rates of heating of land and water are of great importance in modifying the general circulation of the atmosphere. Air that sinks to the earth's surface from the upper levels over the continents in polar regions is very dry and cold, whereas subsiding air over the continents in the Tropics is dry and hot. Air that has traveled some distance over water is moist, and warm or cool depending on its source. Over much of the earth, the circulation consists of alternate invasions of great masses of air from first one and then another source region. Surges of air from polar sources cool the regions into which they advance, whereas those from the Tropics have a warming effect. Whenever warm air collides with cold, the warm air, being lighter, is displaced upward and cooled. If it is moist and is sufficiently cooled, precipitation results. Rainfall on land and sea alike comes largely from maritime air masses. Continental air masses, whether traveling over land or sea, tend to absorb moisture evaporated from the land or sea surface.

As a result of the alternation of continents and oceans over the earth's surface, the pattern of climates is distorted so that the theoretical zoning (fig. 1, *A*) is greatly modified. The two supercontinents of the earth, one comprising the Americas, and the other Eurasia, Africa, Australia, and their island satellites, are separated by superoceans, the Atlantic and the Pacific. In both cases, the land mass is widest north of the Equator, and narrows to a point between 40° and 55° south latitude. Farther to the south is Antarctica.

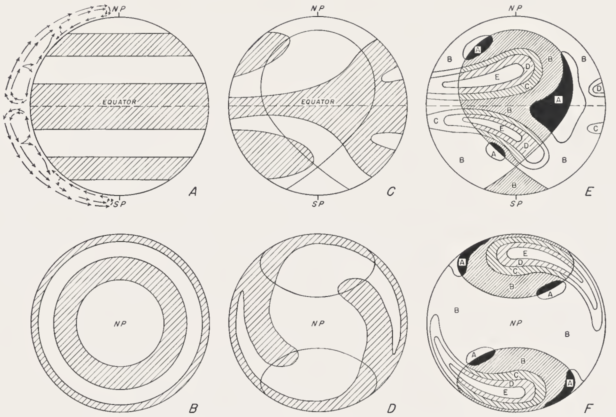

Figure 1.—Diagrammatic representation of the distribution of rainfall and the pattern of climate over the earth.

In figure 1, *C* and *D*, the effect of the alternation of great bodies of land and water is indicated. The area within the loop in figure 1, *C*, represents a much-generalized continental land mass surrounded by water. The triangular area to the south represents Antarctica. The polar view (fig. 1, *D*) shows the portions of the two continents that lie north of the Equator. Again, the areas receiving more and less than 20 inches of rainfall annually are indicated.

The nature of the disturbance of the zonal pattern of climate is best seen by comparing figure 1, *A*, with 1, *C*, and 1, *B*, with 1, *D*. The equatorial rainy belt and the dry polar areas persist, but the subtropical dry belts are joined to the dry polar areas over the continents, and the rainy high middle latitude belts join the equatorial rainy belt along the eastern coasts of the continents. Viewed from the North Pole, as in figure 1, *D*, the dry portion of the hemisphere appears as an enormous *S*, with the body over the polar cap, the two loops over the continents, and the tails extending westward far into the oceans (*1, pl. 18; 2, pp. 18–19; 12, charts 95–110*).[1] Over the oceans and along continental west coasts the zonal arrangement of belts persists, but in the interiors of the continents and along their east coasts rainfall diminishes more or less regularly from the Equator to the Poles.

These diagrams are generalized from actual rainfall observations that are relatively abundant over the lands but are extremely scarce over the oceans. Thus, there is some uncertainty as to the exact position and the westward extension of the dry belt in the subtropical oceans. In the Southern Hemisphere, because of the smaller extent of land, rainfall observations are relatively few and the pattern is far less certain. Theoretically, the view from the South Pole would appear as a reverse *S*, with three tails instead of two extending into the oceans westward from the coasts of South America, South Africa, and Australia. However, because of the virtual absence of land, the rainy belt in high southern latitudes may not be interrupted at all, in which case there would be no connection between these three subtropical dry areas and the dry area over Antarctica. The generalized distribution of rainfall over the earth as given in plate 1 assumes a connection between the dry belt of the Tropics and Antarctica.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 5.

VEGETATION AS A CLIMATIC INDICATOR

Annual precipitation varies enormously over the earth, the minimum being less than 1 inch and the maximum in excess of 900 inches. As a result, types of vegetation have developed that vary greatly in their moisture requirements. At one extreme, the water available for vegetation is vastly more than sufficient for the most extravagant users of water; and at the other, it is insufficient to permit the development of the most abstemious of water-using vegetation. On the basis of moisture requirements, five principal types of vegetation have developed over the earth's surface. Because of their dependence on precipitation for moisture, these vegetation types correspond to climatic regions as follows:

Vegetation type	*Climatic region*
Rain forest	A Superhumid.
Forest	B Humid.
Grassland	C Subhumid.
Steppe	D Semiarid.
Desert	E Arid.

Since some of the water that falls on the land evaporates directly and some runs off from the land back to the sea, only a part of the precipitation is available for plants. This remainder, which the plants may use, is called effective precipitation. Losses due to evaporation and run-off diminish from the Equator to the Poles as temperature decreases, and consequently, the effectiveness of a given amount of rainfall increases. Thus, the diagrammatic representation of the distribution of rainfall in figure 1, *C* and *D*, fails to give an adequate picture of the pattern of climates. Even though the annual rainfall in the polar regions is small, the evaporation is smaller still, and the resultant climate is humid.

At present, no meteorological instrument for measuring effective precipitation exists. Total precipitation falling on any part of the earth can be measured, but the proportion not lost as evaporation or run-off and therefore available for plants cannot be measured directly. Vegetation itself serves as the most satisfactory existing measure of effective precipitation; thus, the five principal climatic types are mapped by means of natural vegetation. The distribution of soil types and, to a lesser degree, patterns of drainage and land surface and of land use verify the fivefold climatic division suggested by the distribution of vegetation.

In figure 1, *E* and *F*, the generalized distribution of the five climatic types is shown, the land areas being shaded from solid black to white to conform to the range from superhumid (A) to arid (E). The relations between figure 1, *C* and *E*, and between 1, *D* and *F*, can readily be seen.

The actual distribution of the five climatic types over the earth is shown in plate 2. Despite the irregularity of the continental outlines as compared with those of the generalized continent in figure 1, *E*, and despite the great variations in elevation, the climates of the land masses are clearly modifications of the basic pattern.

The regions of arid climate in Arizona, southern California, Nevada, Utah, and northern Mexico form a shrunken and foreshortened counterpart of the great arid regions of Eurasia and Africa, which include the Sahara, the Arabian deserts, the deserts of Iran and Turkestan, the Thar Desert of India, and the Gobi Desert of Mongolia. The Southern Hemisphere arid climates include the Atacama Desert of South America, the Kalahari Desert of South Africa, and the Great Australian Desert. Every continental west coast between 20° and 30° from the Equator, both north and south, is arid.

Rain-forest vegetation and superhumid climate appear on equatorial coasts and islands and on continental west coasts between 40° and 60° both north and south of the Equator. The Pacific coast of North America from northern California to Alaska is superhumid, as is also the southern part of Chile in South America. In Europe, the northwest corner of Spain, and the western coastal portions of Ireland, Scotland, and Norway are likewise superhumid. Africa and Australia do not extend sufficiently far south to include corresponding areas of superhumid climate. This climate occurs, however, along the west coast of New Zealand's South Island.

Between the superhumid and the arid regions are belts of humid, subhumid, and semiarid climates of greater or less width. The resulting climatic pattern over the earth, although lacking the simplicity of the zonal arrangement of figure 1, *A*, does not lack in consistency.

THE DETERMINATION OF EFFECTIVE PRECIPITATION

In the absence of direct means for measuring the residual amount of precipitation available for plant growth, attempts to compute it as an index or coefficient in terms of evaporation, temperature, vapor pressure, or other factors have been made by many investigators. Such an attempt is the precipitation effectiveness (*P–E*) index used by Thornthwaite (*10; 11*) in a world classification of climates.

By means of a formula whereby the effectiveness of precipitation is evaluated in terms of the temperature at which it fell, *P–E* indices were computed for all stations in the United States whose precipitation and temperature records extended over a period of 20 years or more. Through actual field observation of vegetation and soil and the study of vegetation and soil maps, the limits of the five humidity provinces were established as follows:

Climatic region	*P–E index*
A Superhumid	128 and above.
B Humid	64 to 127.
C Subhumid	32 to 63.
D Semiarid	16 to 31.
E Arid	Less than 16.

The subhumid climate was subdivided into moist subhumid (Cr) and dry subhumid (Cd) by the *P–E* index of 48. The generalized distribution of these six climatic types in the United States is given in figure 2 and their actual distribution in plate 3.

The climatic regions thus delimited strictly in terms of quantitative precipitation and temperature values correspond in general with vegetation and soils regions. That the boundaries of these climatic regions cannot be defined in terms of inches of rainfall is shown by the following example. The *P–E* isopleth of 32, separating subhumid and semiarid climates, divides the country roughly in half and can be traced from the Canadian border to the Gulf of Mexico. The average annual rainfall and mean annual temperature of a number of stations adjacent to this line are given in table 1. Sixteen inches of precipitation on the Canadian border are seen to be as effective as 26 inches on the coast of the Gulf of Mexico.

TABLE 1.—*Mean annual temperature, mean annual precipitation, and P–E indices of selected stations in the United States*

Station	Mean temperature	Mean precipitation	*P–E* index	Station	Mean temperature	Mean precipitation	*P–E* index
	° *F.*	*Inches*			° *F.*	*Inches*	
Bottineau, N. Dak	36.2	15.60	31.8	Dodge City, Kans	54.2	19.92	31.9
Bismarck, N. Dak	40.3	15.94	33.1	Canadian, Tex	58.1	21.02	31.3
Pierre, S. Dak	47.3	16.00	30.0	Abilene, Tex	64.2	24.51	34.2
Alliance, Nebr	47.0	16.42	31.2	Corpus Christi, Tex	70.8	25.95	32.2
Hoxie, Kans	52.6	19.25	32.1				

The fact that no consideration is given to other climatic factors, such as temperature efficiency [2] or seasonal concentration of rainfall, results in some apparent inconsistencies. As an extreme example, the Greenland and Antarctic ice caps are mapped as humid, although it is recognized that they are not forested regions. The moisture factor is such as to permit the development of forests, but temperature efficiency is so low that there is no vegetation of any sort. Furthermore, if temperature efficiency rose to a level to permit forest growth, precipitation effectiveness would drop unless there were a comparable increase in rainfall.

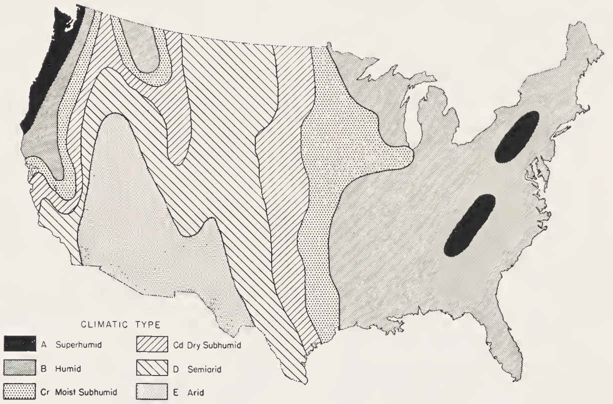

FIGURE 2.—Generalized normal distribution of the principal climatic types in the United States. Compare with plate 3.

The areas in the United States where temperature efficiency is so reduced as to disturb the relation between precipitation effectiveness and vegetation are above timber line on the highest mountains and are so unimportant that they can be ignored.

THE CLIMATES IN THE UNITED STATES

SUPERHUMID CLIMATE

Superhumid or rain-forest climate is of relatively small extent in the United States. The high-latitude west-coast superhumid area of North America includes coastal Washington, Oregon, northern California, and the western slopes of the Cascades and Sierras. The Pacific coast rain forests have been described by Cooper [3] as follows:

> The most striking characteristic of this forest community is the immense average size of the trees. The most characteristic and abundant species, the hemlock, though large enough, is the smallest of the dominants. The lowland fir is but slightly larger. In sharp contrast stands the arbor vitae with its enormous bulk and flaring base. Douglas fir attains its greatest size where mixed with climax trees. Individuals of this species in pure stands are young and therefore small. The survivors of these, found scattered through the climax forest, stand out as individuals of enormous girth, dwarfing all but the arbor vitae. Notwithstanding their great size, the trees of all species are very closely placed, doubtless as a result of abundant germination upon the humus accumulations of the forest floor, together with superabundant moisture, so that elimination through competition is not so severe as in the average forest. I have seen an eleven-foot Douglas fir and a seven-foot arbor vitae standing but three feet apart, and this is by no means an unusual case.
>
> Penetrating the interior of the forest, one is vividly reminded of the moist tropics, and this impression is intensified by the great abundance of epiphytes. These are for the most part mosses of many species, which cling to the trunks and branches in weighty masses. A fern (*Polypodium scouleri* Hook. and Grev.) is also common and characteristic. Other plants, not habitually epiphytic in habit, often appear perched high above the ground. One frequently finds full-grown blueberry bushes, or *Menziesia*—in fact, almost any forest shrub, growing happily in such places. Most surprising of all is the common occurrence of the trees themselves as epiphytes. The hemlock indulges most frequently in this habit, but is by no means the only one, and the arbor vitae seems to furnish the most attractive perching places. On the Olympic foreland, west of Quinault Lake, I found growing from the side of an arbor vitae a thrifty hemlock fifty feet high and ten inches thick. Not far away a western white pine, starting on an arbor vitae forty feet above the ground, had grown into a tree eighty feet high and two feet in diameter. Its roots extended to the ground on all sides of its host's trunk, almost concealing it. Trees beginning life as epiphytes commonly establish an adequate connection with the ground and become permanent members of the dominant stratum, equal in every respect to their companions born in more conventional manner. In such a case the basal part of the "trunk" is a complex of coalesced roots and is usually in consequence swollen and fluted.
>
> Shrubs are abundant everywhere except in the deepest shade of hemlock and arbor vitae. Vine maple is most conspicuous and usually of small-tree size. Its arching trunks frequently bend over till they touch the ground, where they take root. Its leaves turn red in late summer, adding a welcome touch of color to the sombre forest scene. Devil's club is a beautiful but hardly lovable inhabitant, fortunately somewhat localized in ravines and other very moist places. Oregon grape is most evident among the lower shrubs. Of the herbaceous population the various ferns are most important, the tall, handsome sword fern often sharing the forest floor with Oregon grape to the

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[2] For a discussion of temperature efficiency see Thornthwaite (*10, pp. 644–647*).

[3] COOPER, W. S. THE FORESTS OF NORTH AMERICA. [Manuscript.]

exclusion of everything else. Skunk cabbage is common in very wet places; wood sorrel is abundant southward.

The forest floor is a maze of fallen trunks in various stages of disintegration, the oldest recognizable only as elongated mounds, the whole covered and almost concealed by a tangle of shrubs, herbs, and tree seedlings, among which hemlock is immensely preponderant.

A few scattered "islands" of superhumid climate occur also in high parts of the Rockies and the Appalachians.

HUMID CLIMATE

Eastern United States is made up almost entirely of humid or forest climate and, together with southeastern Canada, comprises one of the largest humid regions in the world. In western America humid climate is much less extensive. From central California northward into British Columbia and eastward beyond the crest of the Sierras and the Cascades is a narrow humid belt bordering the superhumid areas. Many elevated areas in the interior Western States have humid climate.

Within the region of humid climate in eastern United States several distinct forest types have developed. In part, they indicate variations in temperature efficiency but in part, also, they indicate variations in effective precipitation. The wide range in effective precipitation between the subhumid and the superhumid boundaries suggests that the humid climate requires further subdivision. Four such moisture subdivisions are shown on small scale in figure 3. Since adequate terms to describe these variations in moisture are not available, they have been designated by subscript as B_5, B_6, B_7, and B_8, the first being adjacent to the moist subhumid and the last to superhumid. These subdivisions of the humid climate are delimited by *P–E* indices of 80, 96, and 112.

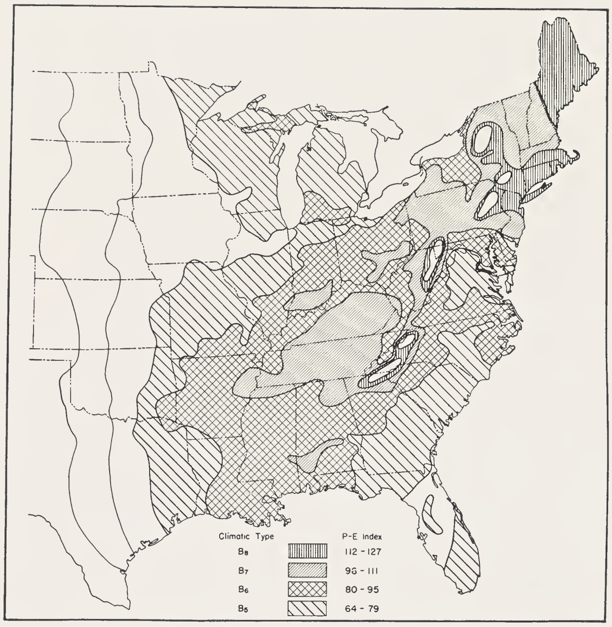

FIGURE 3.—Subdivisions of humid climate in eastern United States. Compare with plate 3.

Within each of these subdivisions there is a northern, or microthermal, and southern, or mesothermal, zone. The forest types associated with these climatic regions are approximately as in table 2.

TABLE 2.—*Moisture subdivisions of humid climate, P–E indices, and characteristic forest types in northern and southern zones in the United States*

Climate	*P–E* index	Northern zone	Southern zone
B_8	112–127	Spruce-fir	(Absent in eastern United States.)
B_7	96–111	Birch-beech-maple-hemlock	Oak-chestnut.
B_6	80–95	Beech-maple	Oak-pine.
B_5	64–79	Oak-hickory	Oak-hickory.

As effective precipitation in the humid climate diminishes the forest becomes more open, and grasses and herbs become relatively more abundant. Near the subhumid boundary, the woodland is made up of scattered trees spaced as in a park.

The dense mixed mesophytic forest of east-central Pennsylvania strongly resembled rain forest in appearance. Theodore Roosevelt (*7, v. 8, p. 92*) described it as it appeared to the pioneer settlers of the early eighteenth century as follows:

> These clearings lay far apart from one another in the wilderness. Up to the door-sills of the log huts stretched the solemn and mysterious forest. There were no openings to break its continuity; nothing but endless leagues on leagues of shadowy, wolf-haunted woodland. The great trees towered aloft till their separate heads were lost in the mass of foliage above, and the rank underbrush choked the spaces between the trunks. On the higher peaks and ridge crests of the mountains there were straggling birches and pines, hemlocks and balsam firs; elsewhere, oaks, chestnuts, hickories, maples, beeches, walnuts, and great tulip-trees grew side by side with many other kinds. The sunlight could not penetrate the roofed archway of murmuring leaves; through the gray aisles of the forest men walked always in a kind of midday gloaming.

This is in sharp contrast to the appearance of the forests in the drier parts of the humid climate. Peter Kalm (*4, v. 1, p. 87*), in 1748, commented on the openness of the forests near Philadelphia as follows:

> The country on both sides of the road was covered with a great forest. The trees were all with annual leaves, and I did not see a single fir or pine. Most of the trees were different sorts of oak. But we likewise saw chestnut trees, walnut trees, locust trees, apple trees, hiccory, blackberry bushes, and the like. The ground ceased to be so even as it was before, and began to look more like the *English* ground, diversified with hills and vallies. We found neither mountains nor great stones, and the wood was so much thinned, and the ground so uniformly even, that we could see a great way between the trees, under which we rode without any inconvenience; for there were no bushes to stop us.

In upper South Carolina the original forest was likewise open, as is indicated by the following description by John H. Logan (*5, p. 7*):

> As late as 1775, the woodlands, carpeted with grass, and the wild pea-vine, growing as high as a horse's back, and wild flowers of every hue, were the constant admiration of the traveler and adventurous pioneer. The forests of those early times were far more imposing than any now remaining in this portion of the ancient Cherokee Nation. The trees were generally larger, and stood so wide apart that a deer or a buffalo could be easily seen at a long distance—there being nothing to obstruct the view but the rolling surface. On the elevated hill-tops the strolling hunter often took his stand, to sweep, at a single view, a large extent of country. The pea-vine and grasses occupied the place of the bushes and young forest growth that render the woods of the present time so gloomy and intricate.

In the tension zone between forest and grassland on the subhumid boundary of the humid climate the openness of the woodland was one of its most striking characteristics. The oak-hickory woodland of central Wisconsin, as it appeared in 1834, was described as follows (*6, pp. 371–373*):

> The ride to-day was delightful to me, for everything was new and pleasant, the trail running on a ridge of land fifty to seventy-five feet above the River, covered with scattered oaks, like an orchard, the ground bedecked with brightest flowers, and descending gradually to the River, which is a broad, beautiful stream; and on the opposite side the banks were covered with a dense forest. Riding over the prairies or openings on the jump through such scenery, on a narrow footpath, was something delightful to me. * * *
>
> About half a mile farther on, we struck the prairie, which to me was a beautiful sight. Here we could see a grass plat for four or five miles, and not a tree or bush on it. Then again, as we passed on, we would see orchards, as it were, the grass up to our horses' mouths, so that they would nip it as we rode upon the jump. We soon came upon the bank of Lake Winnebago, which is about fifteen miles wide and thirty long; here we found an Indian encampment. * * *
>
> We passed over some fine prairies. In many places they looked like cultivated fields. We would see an orchard in the distance, and before I knew it I was frequently looking for the house, not realizing there was none within from twenty to fifty miles of us.

SUBHUMID CLIMATES

Extending from the Gulf of Mexico north through central United States into Canada are two parallel belts of subhumid climates—an eastern moist-subhumid and a western dry-subhumid belt. Both are tall-grass prairie, originally covered with grasses 3 to 12 or more feet high. Throughout the eastern prairie the characteristic cover was bluestem sod, whereas, in the western prairie, three distinct types ranging from north to south were needlegrass-slender wheatgrass, bluestem bunchgrass, and mesquite and mesquite grass savanna. Sandgrass and sand sagebrush covered the sandier parts of the western prairie (*9*).

The moist- and dry-subhumid climates are separated by a line along which, in ordinary years, rainfall does not exceed the losses by evaporation and the needs of plants, and no water is available as surface run-off. Consequently, in the western prairie, there is no accretion to ground water, except in rainy years; and thus the subsoil is virtually permanently dry. In the eastern prairie, by contrast, there is a precipitation surplus; thus, a moist subsoil, accretion to ground water, and run-off result. For these reasons, some ecologists consider the moist-subhumid a forest climate zone from which forests have been excluded by nonclimatic factors such as fires and possibly buffaloes.

Where evaporation equals precipitation, run-off is limited to periods of intense rain, and water accumulation in the soil is limited to a few inches or feet near the surface, leaving a zone beneath that remains permanently dry. Where precipitation exceeds evaporation water percolates into and through the soil and the surplus flows away over the surface as run-off. These climatic relations have a recognized, direct effect on soil formation and account for the development of the two major soil groups: (1) Lime-accumulating soils, or Pedocals, where the soil water is lost by evaporation and transpiration and the soluble soil materials are not leached out and carried away but are concentrated a short distance beneath the surface; and (2) aluminum-and-iron-accumulating soils, or Pedalfers, where precipitation exceeds run-off and the more soluble materials are leached out, leaving only relatively insoluble matter such as iron and aluminum. The dividing line between the moist-subhumid and the dry-subhumid climates also separates the Pedalfers from the Pedocals.

In the dry-subhumid area is the Chernozem, a soil of the Pedocal group, dark brown to black in color, high in organic matter and plant nutrients, and with an excellent structure. In the moist-subhumid area to the east, where the more abundant precipitation produces a moist subsoil and prevents the accumulation of a zone of lime, Chernozems give way to Prairie soils. These are two of the world's most fertile soil belts.

The natural vegetation of the dry-subhumid climate of west-central Oklahoma was described by Jackson and Cole (*3, pp. 70–71*) as follows:

> Glancing over thousands of acres covered with tall grass and dotted with groves, it appears the perfect counterfeit of cultivated fields and orchards. One can hardly persuade himself that he is not scouring a long-settled country, whose inhabitants have suddenly disappeared, taking with them houses and barns, and leaving only the rich pastures and hay-fields. Wagon roads, revealing the jet-black soil, intersect the deep green of graceful slopes, where moves tall prairie-grass with wild flowers of blue, purple, and yellow. Hundreds of acres of these blossoms predominate, making the earth blue or yellow instead of green. In the spring bloom the flowers of modest, delicate hues; in late summer those of a deep, gorgeous color flame; and in early autumn nature revels in beauty for beauty's sake alone.
>
> Stretching away as far as the eye can reach lies a level and most beautiful plain, covered with thick growth of vegetation and fragrant flowers, nude of timber or brush, and ready for the plow, until you reach the river-banks, which are skirted with large, fine, and straight timber, consisting of walnut, oak, ash, beech, hackberry, hickory, etc.

Smaller areas of subhumid climate occur elsewhere in the United States. A part of peninsular Florida falls just below the minimum requirements for humid climate and is thus in the tension zone between forest and grassland. The California Coast Ranges between San Francisco and Los Angeles and most of the Sacramento Valley are subhumid. Here, the marked winter concentration of rainfall and its almost complete absence in summer produces a significant modification in climatic type (*10, p. 641*).

A continuous subhumid belt extends from California northward along the east slopes of the Sierras and the Cascades into British Columbia, and thence, after skirting the northern Rockies, returns to Canada in the Prairie Provinces and finally joins the subhumid areas of North Dakota and Minnesota. Within this great subhumid loop, the climates in general are semiarid and arid, although in many of the more elevated areas moister climate prevails. Subhumid climate also occurs as a ring on slopes around most central mountainous humid areas.

SEMIARID CLIMATE

Except for the narrow bands of more rainy climates paralleling the coast, semiarid climate dominates in western United States. East of the Rockies, the semiarid Great Plains extend in a continuous belt 300 to 600 miles wide from the latitude of Mexico City north across the United States and 300 miles into Saskatchewan and Alberta.

Shantz (*8, pp. 89, 91*) has described the vegetation of the Great Plains as follows:

> The typical appearance of this grassland as a whole is that of a closely pastured meadow. Except during years of more than normal rainfall the taller growing plants are almost entirely absent, and the vegetation presents the appearance of extreme monotony. There is little variation in appearance from north to south or east to west. Changes in the vegetation within the area are due largely to differences in soil texture, run-off or flood-water irrigation which affect the available soil moisture supply.
>
> The transition to the tall-grass formation is gradual on the east where many of the taller plants occur. On the west many species characteristic of the foot-hill region enter and modify the pure short-grass cover which is characteristic of the central portion of the area.
>
> In spring the short grasses start growth as soon as temperature conditions are favorable. Many flowering plants vary the monotony of the short-grass cover. If the season is unusually dry these plants are usually inconspicuous, and even the short grasses may fail to put up flower stalks. If the season is unusually moist annuals and herbaceous perennials often become a prominent component of the vegetation.
>
> * * * * * * *
>
> The stored soil moisture and the rainfall of spring and early summer enable growth to continue until early in July. At that time practically all of the stored water and that added by the rains has been consumed. The plants then pass into a drought-rest condition which may be broken occasionally by summer or fall rains. During exceptionally wet years, growth may continue almost without interruption throughout the whole season. In extremely dry years, the period during which moisture is available in the soil may be so short that even the buffalo grass, which can flower within 30 days, is prevented from flowering. The dominant species of this formation are without exception drought-enduring plants. They are able to grow rapidly during periods when moisture is available and to pass into a dormant condition when drought occurs. They resume growth quickly when moisture is again supplied. The majority of the annuals can ripen seed during a very short season of growth and are able to produce a few seeds even during the drier years. In such years the plants are depauperate. During wet seasons these annuals may form an extensive portion of the vegetation cover.

Much of the region between the Rockies and the Sierras and Cascades is also semiarid. The coastal valleys of southern California and most of the San Joaquin Valley, as well as a small part of the Sacramento Valley, are likewise semiarid.

ARID CLIMATE

The arid regions as generalized on figure 2 actually consist of two large continuous deserts and a number of smaller isolated areas. One of the large areas includes the Laguna district of Durango, Chihuahua, and Coahuila in Mexico and the adjacent sections of Texas, New Mexico, and Arizona, extending up the Rio Grande to the headwaters in Colorado, and up the Pecos in Texas. The other large desert region includes both coasts of the Gulf of California, with most of the peninsula of Lower California on the west and about half of Sonora on the east. Within the United States, it includes the southwestern third of Arizona, the eastern part of southern California, and about half of Nevada. A number of smaller desert areas are present in various Western States. Among these are the southern part of the San Joaquin Valley in California, the lower Yakima Valley, and a short reach of the Columbia above the junction of the Yakima in eastern Washington, the Great Salt Lake Desert in western Utah, and the Colorado and San Juan Valleys in southeastern Utah, part of upper Green River Valley in southwestern Wyoming, and the Big Horn Basin in north-central Wyoming.

The area of arid climate in the Americas is small in comparison to that of other continents. Whereas 44 percent of Australia and 20 percent of Eurasia and Africa are arid, the proportion in South America is 6 percent and in North America only 4 percent. In the United States the arid areas are widely scattered and amount to only 8 percent of the total. Because of their scattered distribution and their usual proximity to humid mountainous areas, the arid lands of the United States are more subject to reclamation by irrigation than those elsewhere.

The position of the climatic zones during the crop season (March through August), as shown in plate 4, differs somewhat from their annual distribution.[4] In the western part of the Corn Belt in particular, the summer concentration of rainfall is sufficient to push the humid climate west across Iowa into eastern Nebraska. The subhumid climates are similarly pushed westward in the northern Great Plains. On the other hand, in the lower peninsula of Michigan, the crop-season climate drops from humid to moist subhumid. In the Pacific States and in the Southwest summer rainfall is normally so markedly deficient that the climate in the period March through August is almost everywhere arid or semiarid. Since the distribution of climate during the warmer months has no significance in this region of winter rain it has been omitted from plate 4.

CLIMATIC VARIATION

A normal characteristic of all climate is variation. Few places in the United States every year have the climate indicated in plate 3. In the subhumid and semiarid areas the range may be from arid to humid from one year to another, and it may be nearly as great in some desert areas. Moreover, there is a great difference in the frequency of occurrence of the various climates, as is illustrated in table 3.

The yearly fluctuation of climate within wide limits in semiarid and dry-subhumid areas, as at San Antonio, Tex., creates one of the most serious of the climatic risks to agriculture. In some years the amount and seasonal distribution of rainfall are entirely adequate for successful agriculture; in others, the rainfall is so meager that crop production is impossible. No corresponding risk exists in arid climates, as at Indio, Calif., because no year has a climate that would encourage an attempt at nonirrigation agriculture.

TABLE 3.—*Climatic variability at selected stations in the United States, 1900–1939*

Station	Prevailing climate, 1900-1939	Frequency distribution of the climates					
		Superhumid	Humid	Moist subhumid	Dry subhumid	Semiarid	Arid
		Years	*Years*	*Years*	*Years*	*Years*	*Years*
Aberdeen, Wash	Superhumid	40	0	0	0	0	0
Blue Canyon, Calif	do	28	11	1	0	0	0
Newport, Tenn	Humid	0	40	0	0	0	0
Knoxville, Tenn	do	0	39	1	0	0	0
Bay City, Mich	do	2	24	11	3	0	0
Minneapolis, Minn	Moist subhumid	0	14	20	5	1	0
Topeka, Kans	do	0	13	18	8	1	0
Fremont, Nebr	do	0	9	18	12	1	0
San Antonio, Tex	Dry subhumid	0	1	5	22	11	1
Salt Lake City, Utah	do	0	2	3	26	9	0
Walla Walla, Wash	do	0	1	2	24	13	0
Cheyenne, Wyo	do	0	0	4	25	11	0
Bismarck, N. Dak	do	0	0	0	21	17	2
Los Angeles, Calif	Semiarid	0	0	2	12	16	10
Miles City, Mont	do	0	0	1	11	25	3
Havre, Mont	do	0	0	0	15	24	1
Grand Junction, Colo	do	0	0	0	1	24	15
Independence, Calif	Arid	0	0	1	2	1	36
El Paso, Tex	do	0	0	0	0	3	37
Indio, Calif	do	0	0	0	0	0	40

The distribution of climatic types for each year and each crop season from 1900 to 1939 is shown in plates 5 to 84.

The generalized distribution of climates for a few extreme years is shown in figures 4 to 7. If compared with the average position of the climates as shown in plate 3 it will be seen that 1905 and 1915 were unusually rainy, whereas 1910 and 1934 were dry. In the 2 wet years, arid and semiarid climates were very greatly contracted and humid and superhumid climates greatly expanded. During the dry years, the arid and semiarid climates were expanded and the humid and superhumid contracted. Regardless of the shifts in position of the individual climates, however, the characteristic pattern was preserved.

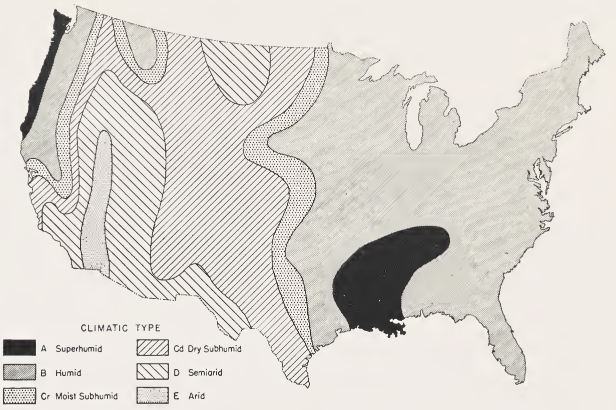

FIGURE 4.—Generalized distribution of the principal climatic types in the United States in 1905. Compare with plate 15.

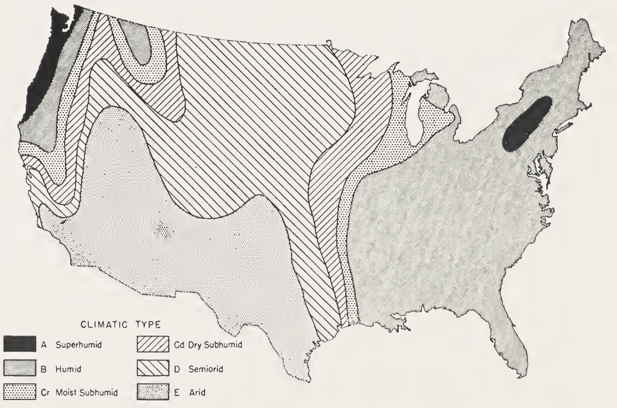

FIGURE 5.—Generalized distribution of the principal climatic types in the United States in 1910. Compare with plate 25.

On the detailed maps showing the distribution of climates for individual years (pls. 5–84) the climatic pattern is always apparent despite great irregularity of the various climatic belts.

The climatic boundaries for individual years are very irregular as compared with their average position and are even more irregular for the crop season than for the entire year. Monthly and annual precipitation totals result from individual rainstorms coming at irregular intervals and varying in position and size, both in areal dimensions and in amount of rain. Thus, variation in climate from year to year traces back eventually to variation in the pattern of rainfall and this, in turn, to variations in the interactions of the great air masses coming alternately from tropical and polar regions and from the sea and the continental interior.

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[4] Crop season climates are determined by computing $P\text{-}E$ indices for the 6 months, March through August, and using as limits values of $P\text{-}E$ one-half those used for the annual maps.

A few small areas in the United States, as at Aberdeen, Wash. (table 3), are always superhumid (pl. 95). Although the annual rainfall at Aberdeen has varied from 50 inches to more than 100 inches, there never has been so little as to produce humid rather than superhumid climate. Similarly, a few small areas, as at Newport, Tenn., have been humid (pl. 93), and other areas, as at Indio, Calif., have been arid (pl. 85) every one of the 40 years. With increase in the length of the record, the areas without climatic fluctuation will become smaller.

Throughout most of the United States there are year to year climatic fluctuations of greater or less magnitude. For instance, the magnitude of fluctuation in Knoxville, Tenn., is small, but that in San Antonio, Tex., is large (table 3). In an area where the range of fluctuation is considerable, it is to be expected that the climate in a given period will be either moister or drier than in an earlier or later period. This is illustrated by the climatic variations at Las Animas, Colo., and Bismarck, N. Dak. (table 4). At Las Animas, during the 25-year period ending in 1909, there were 19 semiarid and 6 arid years; whereas, in the following 25-year period there were 5 dry-subhumid, 17 semiarid, and 3 arid years. The latter was the more moist period. In Bismarck, during the 25-year period ending in 1909, there were 16 dry-subhumid and 9 semiarid years; and during the following period there were 9 dry-subhumid, 15 semiarid, and 1 arid years. The first period was the more moist. Although Bismarck is a dry-subhumid station for the period 1900 to 1939, it rated as semiarid between 1910 and 1934.

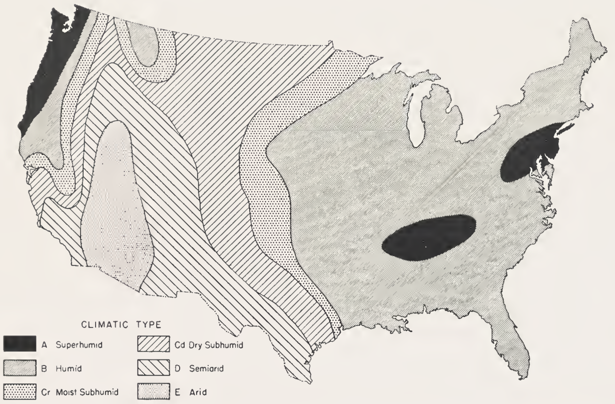

Figure 6.—Generalized distribution of the principal climatic types in the United States in 1915. Compare with plate 35.

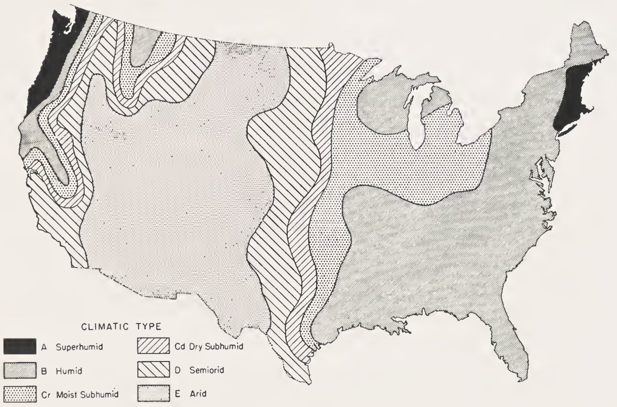

Figure 7.—Generalized distribution of the principal climatic types in the United States in 1934. Compare with plate 73.

Table 4.—*Climatic variability for selected periods, Las Animas, Colo., and Bismarck, N. Dak.*

Station	Period	Prevailing climate	Frequency distribution of the climates					
			Super-humid	Humid	Moist sub-humid	Dry sub-humid	Semi-arid	Arid
			Years	*Years*	*Years*	*Years*	*Years*	*Years*
Las Animas, Colo.	1885-1909	Semiarid	0	0	0	0	19	6
	1910-1934	do	0	0	0	5	17	3
Bismarck, N. Dak.	1885-1909	Dry subhumid	0	0	0	16	9	0
	1910-1934	Semiarid	0	0	0	9	15	1

A shift in frequency of occurrence of climatic types as at Las Animas and Bismarck in these two periods does not constitute a climatic change, nor does it represent a climatic trend. It is rather an expression of chance distribution of abnormally moist or dry years.

Climatic changes of very great magnitude have occurred in the past. They are probably occurring now. But climatic change involves the permanent dislocation of the climatic pattern of plate 2, which requires change in the general atmospheric circulation, or in the size and orientation of the land masses. Climatic changes, therefore, must be extremely slow and are so completely masked by year to year climatic fluctuations that no existing instrumental weather record is long enough to reveal them.

The frequency of occurrence of the various climatic types is shown in plates 85 to 96. The maps are based on only a 40-year record and probably do not give the long-time frequencies exactly. They cannot be revised until more records have accumulated. Thus, they should be interpreted as representing the most probable frequencies to be expected in the next 40 years. Only the frequencies of arid, humid, and superhumid climates are shown individually; the semiarid and the two subhumid climates are presented so as to show the combined frequencies of the specified type with all drier types.

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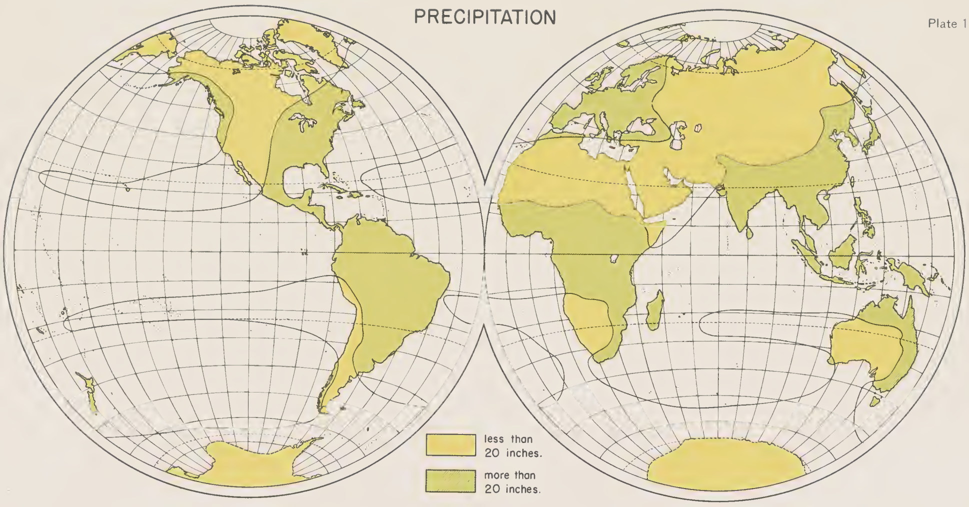
PRECIPITATION

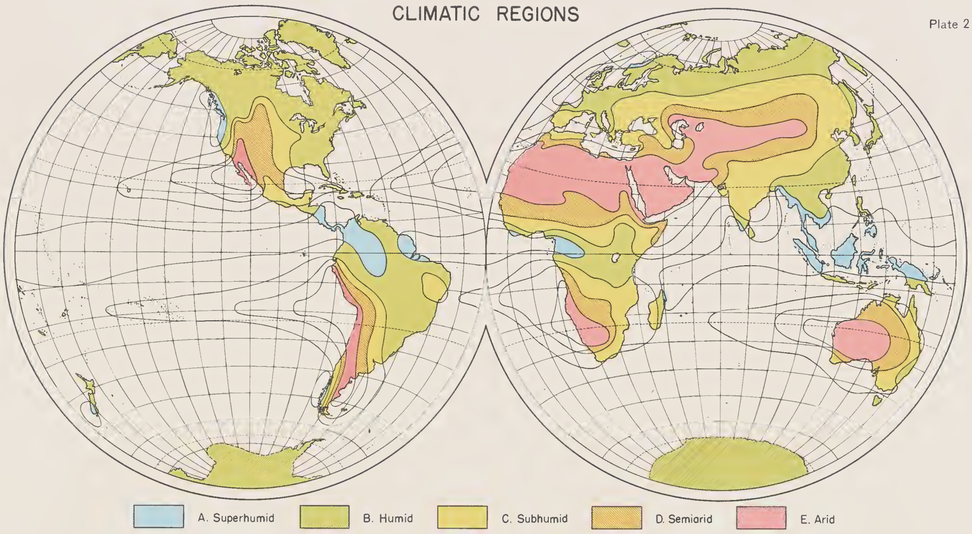
Plate 1



Generalized distribution of average annual precipitation over the earth (inferred in part over the oceans). There are many excellent maps showing the distribution of rainfall on the land (2, pp. 18–19), but information for the oceans is extremely sketchy. Sources of information for the oceans were Bartholomew (1, pl. 18) and the Weather Bureau atlas (12, charts 95–110).

CLIMATIC REGIONS

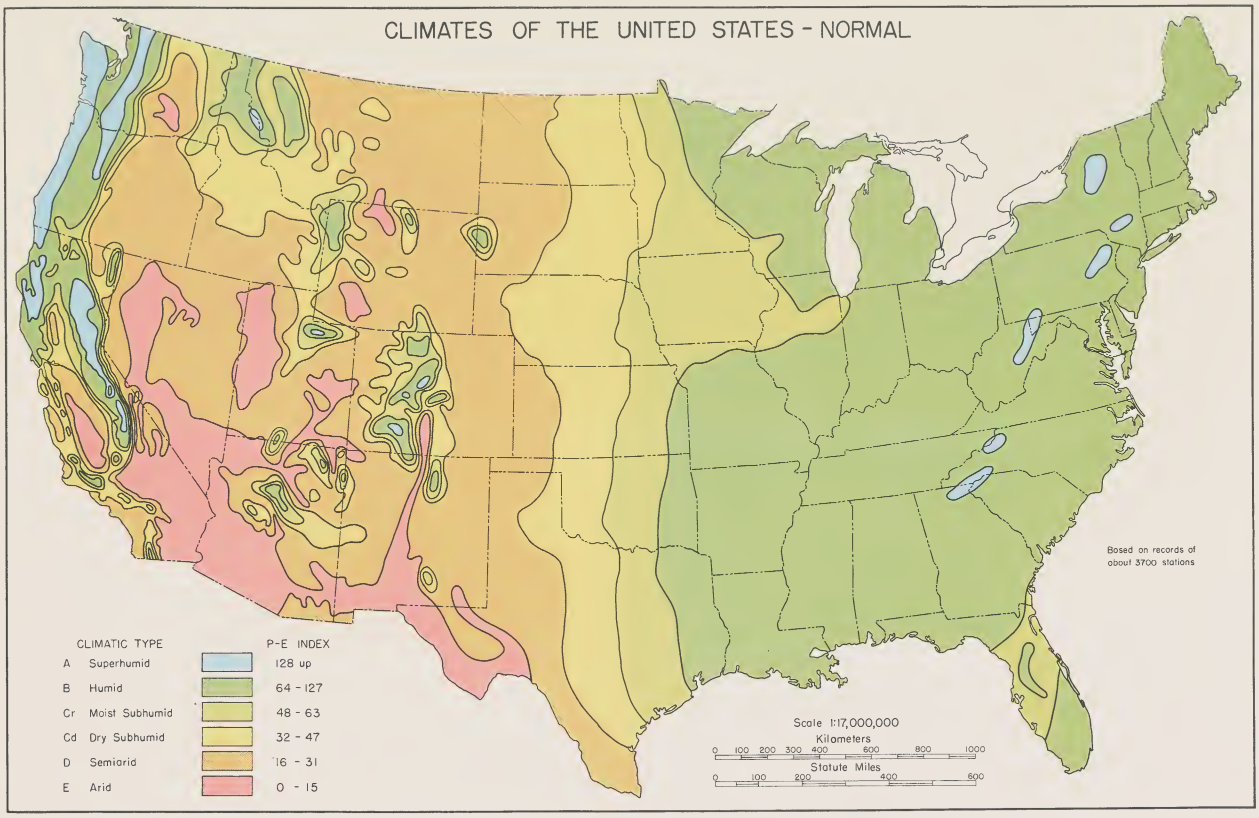
Plate 2



A. HOEN & CO.

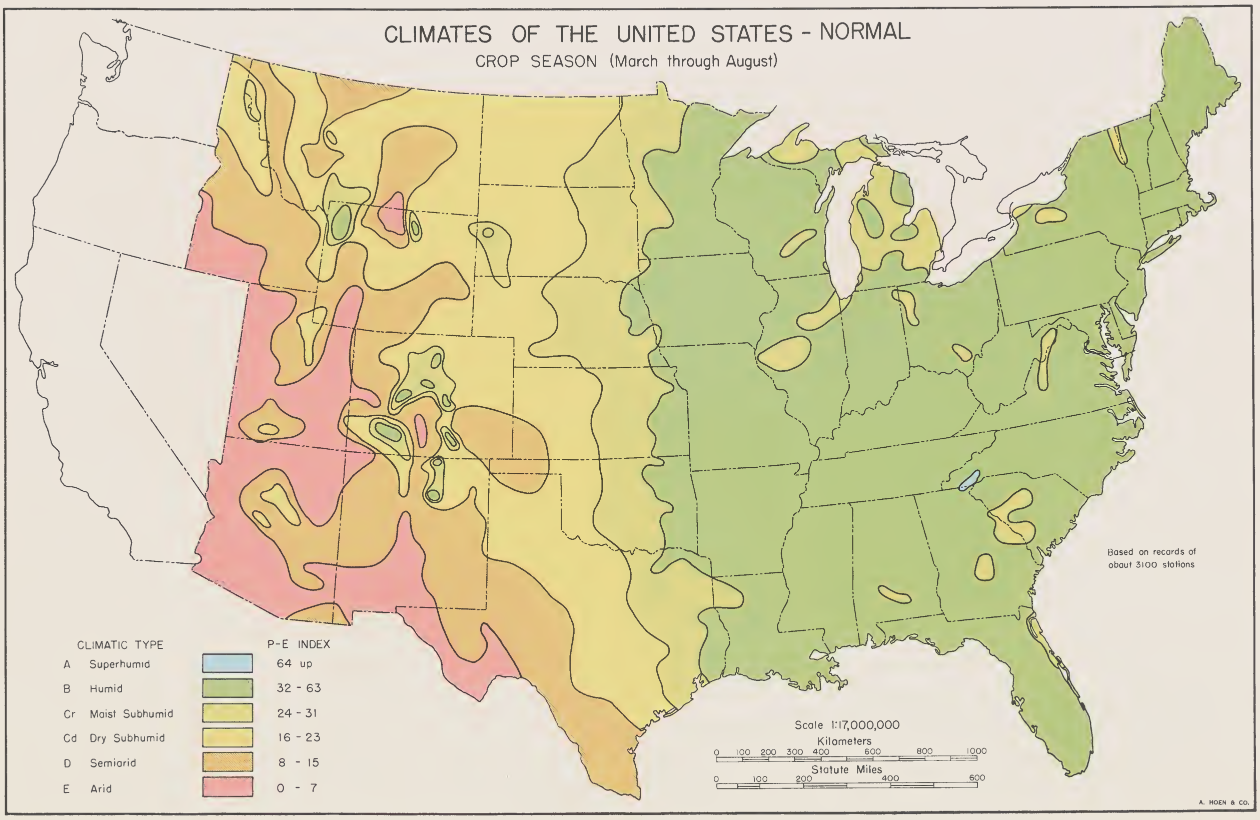
Generalized distribution of climatic regions over the earth, adapted and simplified from Thornthwaite's (11) map of world climate.

Plate 3



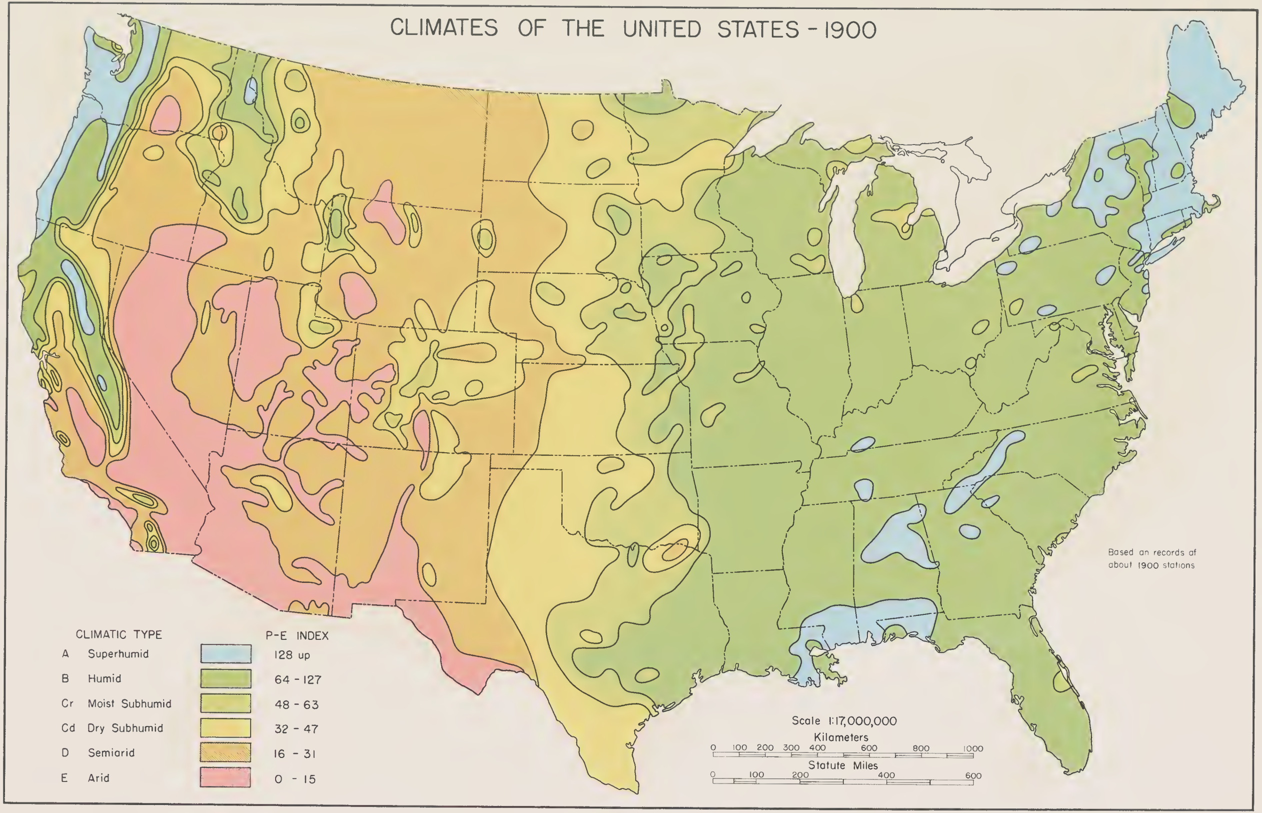
Normal distribution of the principal climates in the United States. Superhumid climate occurs along the Pacific coast of Washington, Oregon, and northern California, on the western slopes of the Cascades and Sierras, and on high elevations in the Rockies and the Appalachians. Humid climate is most extensive in the East, but it also occurs adjacent to superhumid climate on the Pacific coast and on high areas elsewhere in the West. Subhumid climates are most extensive in the Middle West, wide belts of moist subhumid and dry subhumid extending from the Gulf coast of Texas to the Canadian border in Minnesota and North Dakota. Other smaller subhumid areas occur in the West. The Great Plains and much of the intermountain region are semiarid. Arid climate is most extensive in the Southwest.

Plate 4



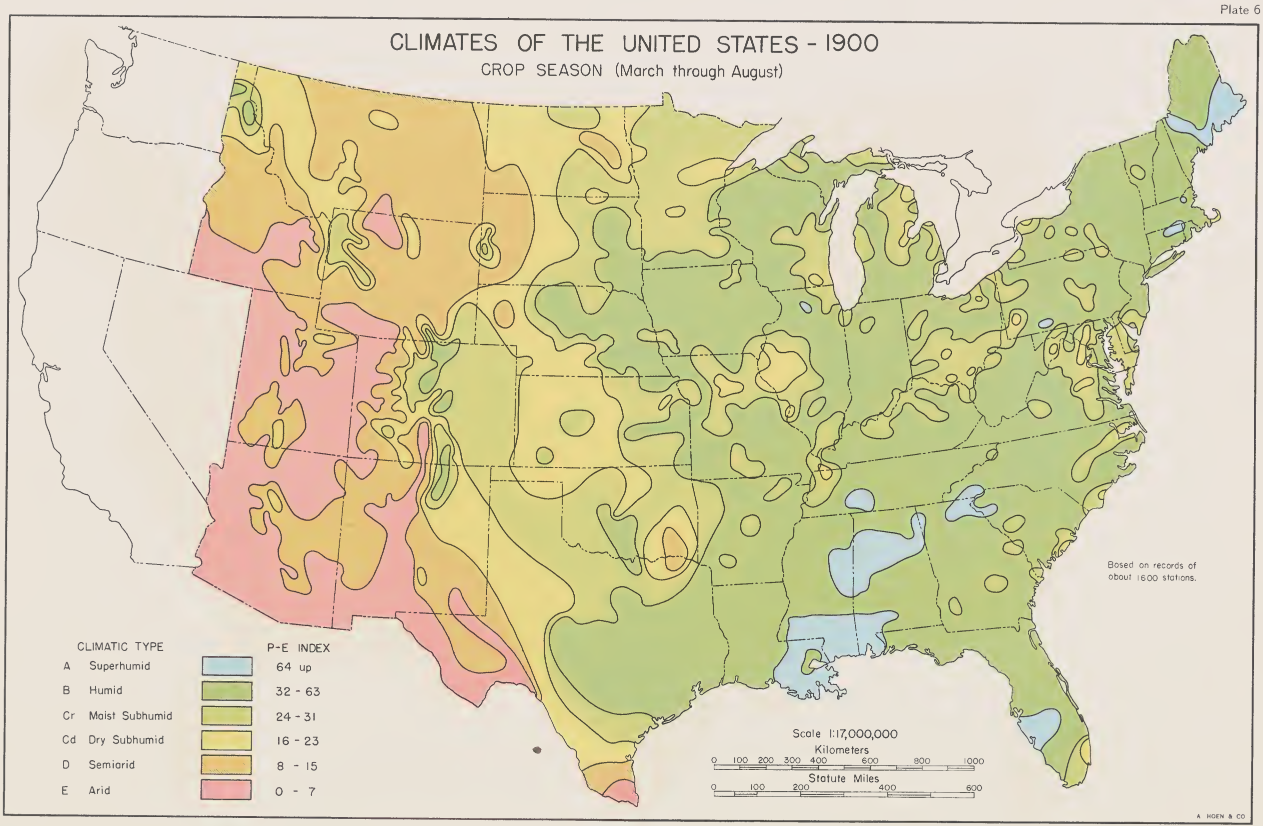
The normal distribution of climate in the crop season is similar to the normal annual distribution. Humid climate is expanded westward and occupies most of Iowa and Minnesota. It displaces the moist-subhumid belt westward, especially in Nebraska and the Dakotas. Dry-subhumid climate occupies most of the Great Plains, and semiarid climate is much reduced in area. In the Pacific States and in Nevada, summer rainfall is normally markedly deficient. Since the distribution of climate for the period March through August in the region of winter rain is not comparable to that of the rest of the country it has been omitted.

Plate 5



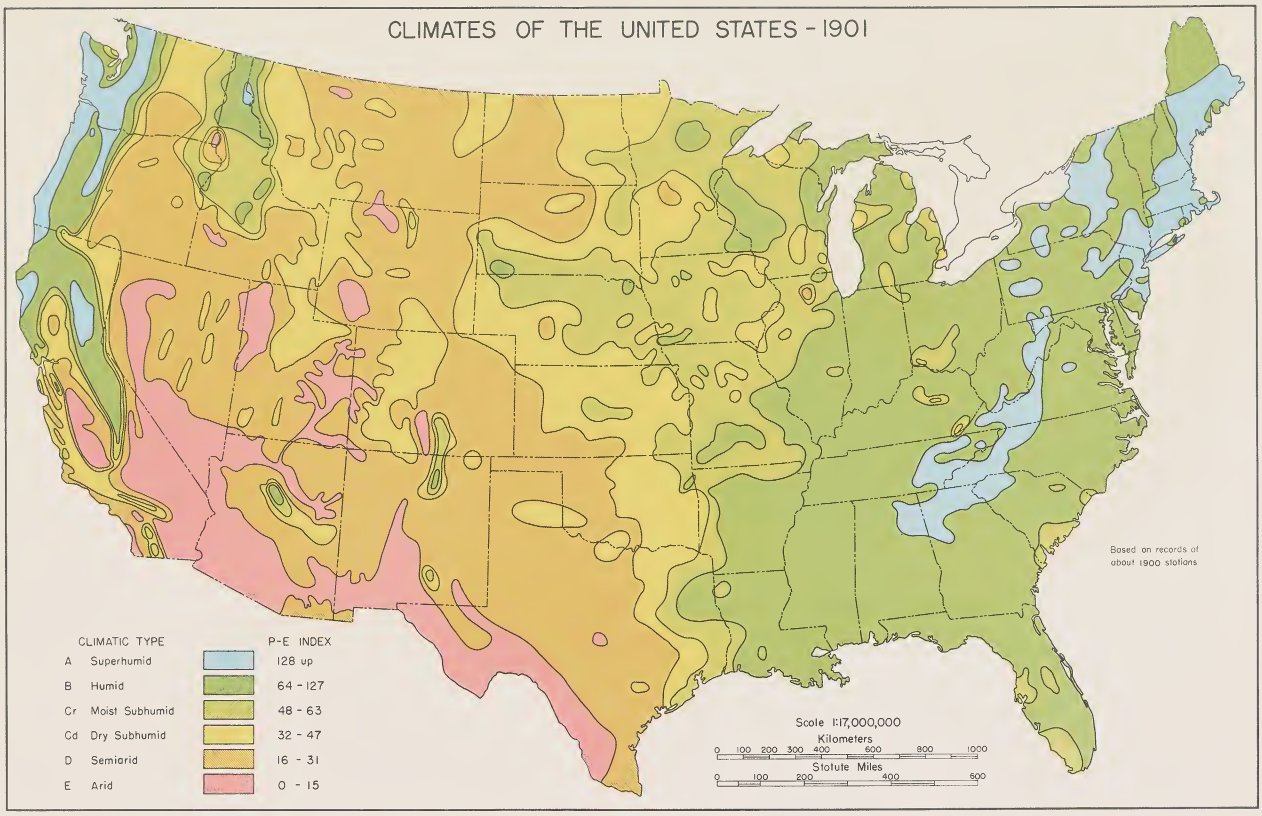
In 1900 the superhumid climate was more extensive than usual, occupying most of New England and several isolated small areas in the Gulf and South Atlantic States. Humid climate pushed westward across Illinois and most of Iowa. In southeastern Oklahoma and northeastern Texas, a small area ordinarily humid was semiarid. A narrow finger of dry-subhumid climate pushed eastward across Minnesota to the shores of Lake Superior. The climatic pattern in the western half of the United States was generally normal. Arid climate was present along the coast of southern California.

Plate 6



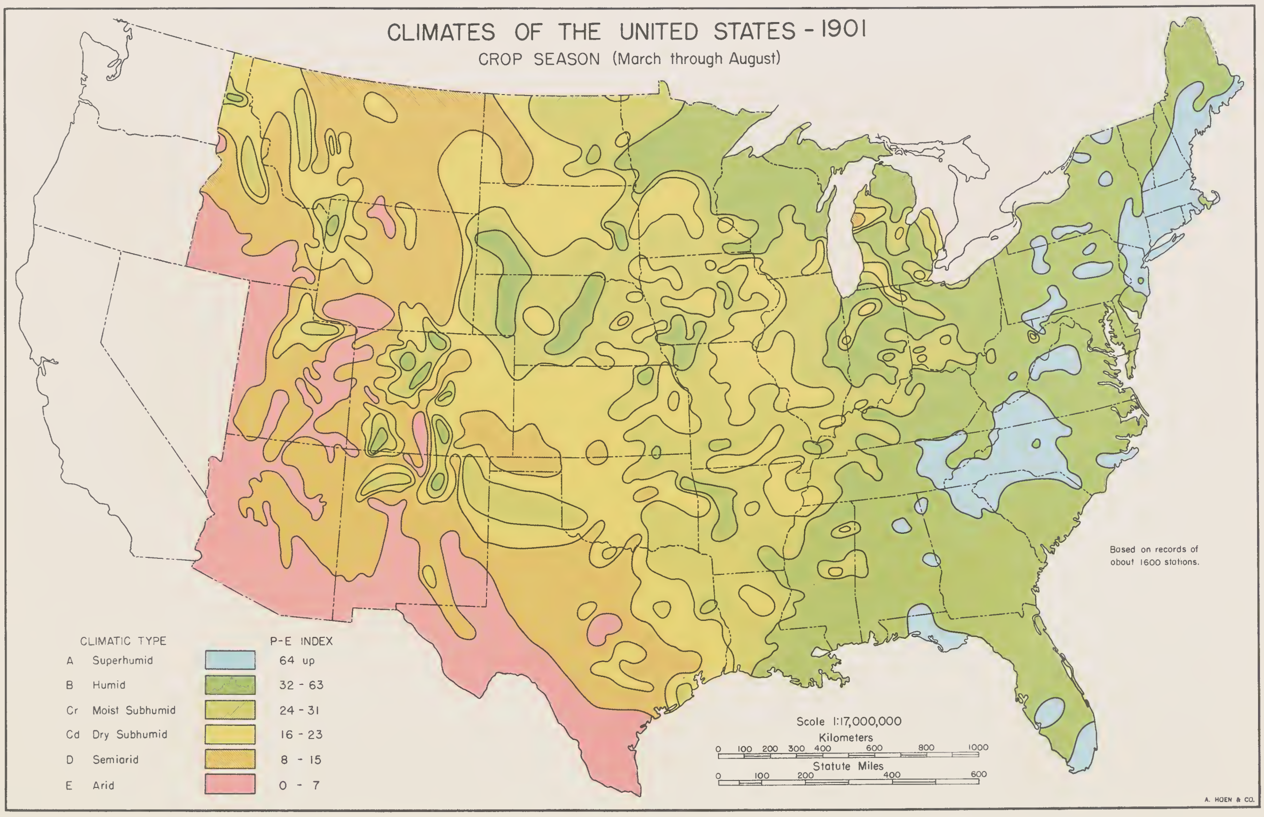
During the crop season of 1900 a number of relatively small areas of subhumid climate appeared in the Ohio Valley, the Lake States, and the Middle Atlantic States. On the other hand, a lobe of humid climate extended westward into middle Nebraska and South Dakota. Another humid lobe extended far west into Texas. Moist-subhumid climate extended northwestward across the Texas and Oklahoma Panhandles and occupied all of eastern Colorado. Southeastern Oklahoma was semiarid. Several superhumid areas appeared in the Southeastern States.

Plate 7



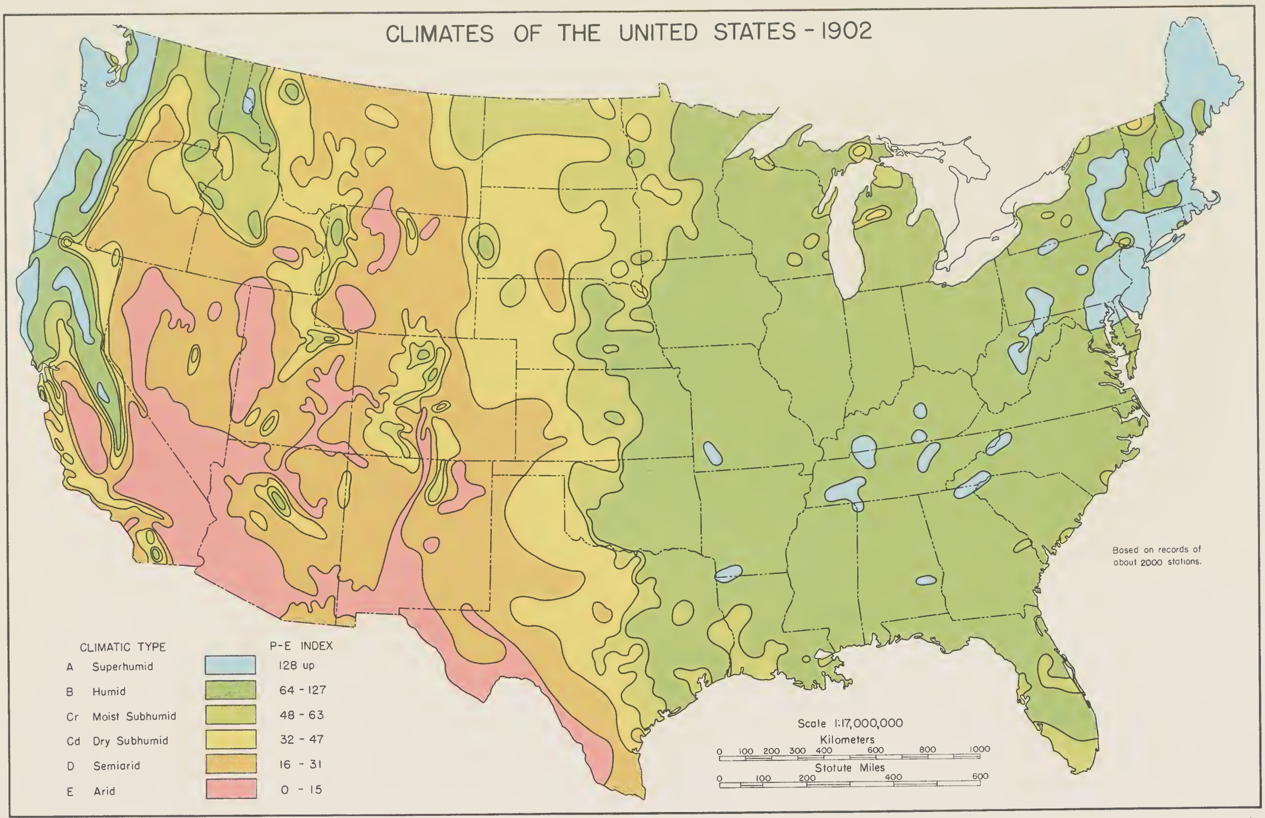
In 1901 superhumid climate was again more extensive in eastern United States than usual. Coastal New England, New York, and New Jersey, and the Appalachians from Pennsylvania to Alabama were superhumid. The moist-subhumid climate was more extensive in the North Central States than usual, a lobe extending across Nebraska and South Dakota. In the southern Plains semiarid climate pushed eastward into central Oklahoma and eastern Texas and arid climate extended down the Rio Grande nearly to the Gulf. Small arid areas appeared in central Texas and north-central Montana.

Plate 8



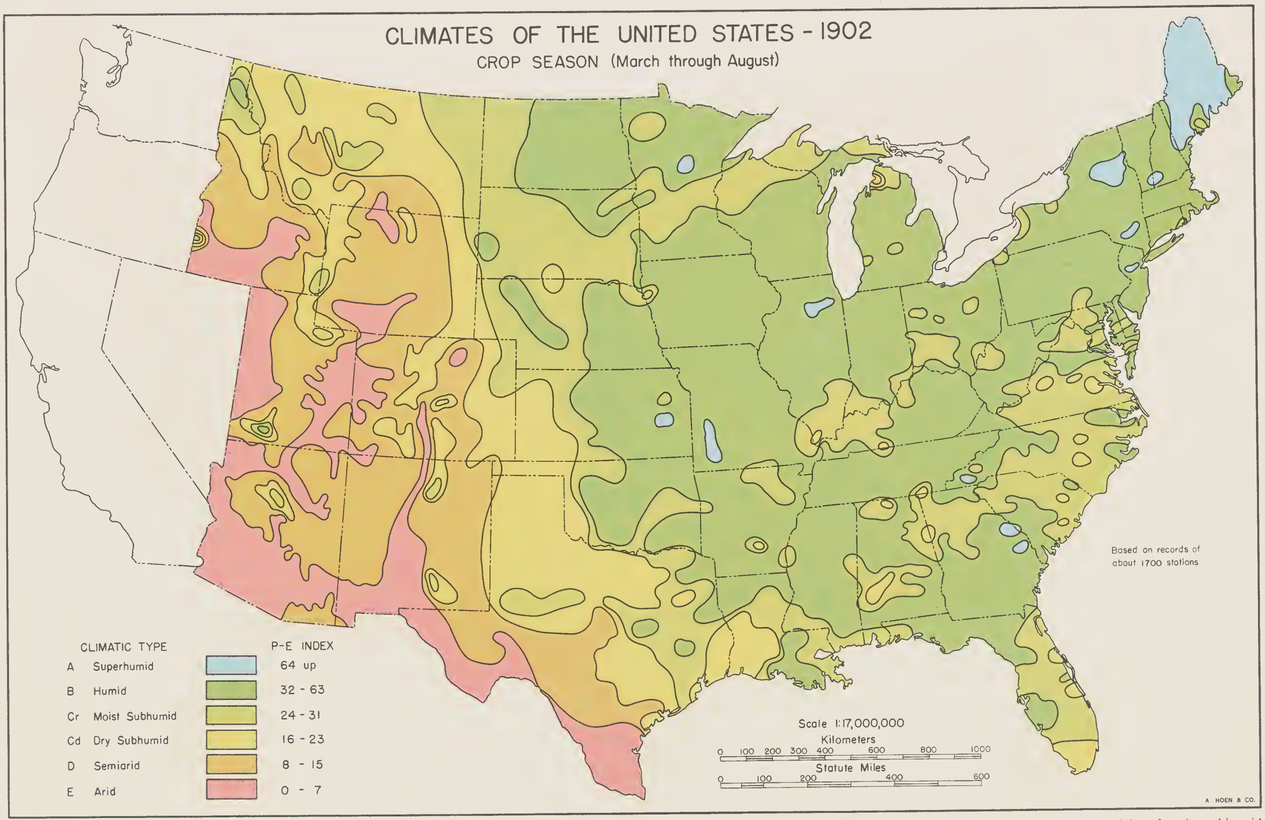
During the crop season of 1901 there were large areas of superhumid climate in the eastern part of the country. In the area neighboring the Mississippi River great areal variability occurred. Humid islands appeared as far west as western Nebraska and South Dakota. On the other hand, a small area of semiarid climate appeared in the lower peninsula of Michigan. Arid climate occupied much of southwest Texas and a small area in the central part of the State. A large moist-subhumid area occupied much of the Texas Panhandle, whereas the Oklahoma Panhandle and neighboring parts of Colorado and Kansas remained semiarid.

Plate 9


CLIMATES OF THE UNITED STATES - 1902

In 1902 the humid climate extended west into central United States considerably beyond its usual limit and the belt of moist-subhumid climate nearly disappeared except in the northern prairie region. The dry-subhumid belt was displaced generally to the west, and the semiarid belt east of the Rockies was considerably narrower than usual. Islands of superhumid climate appeared from Arkansas and Missouri northeastward to Maine. There were small arid areas in northeastern Wyoming and northeastern New Mexico. Superhumid climate was more extensive than usual in the Pacific Northwest; the arid area in eastern Washington was missing, and the intermediate climates were appropriately displaced.

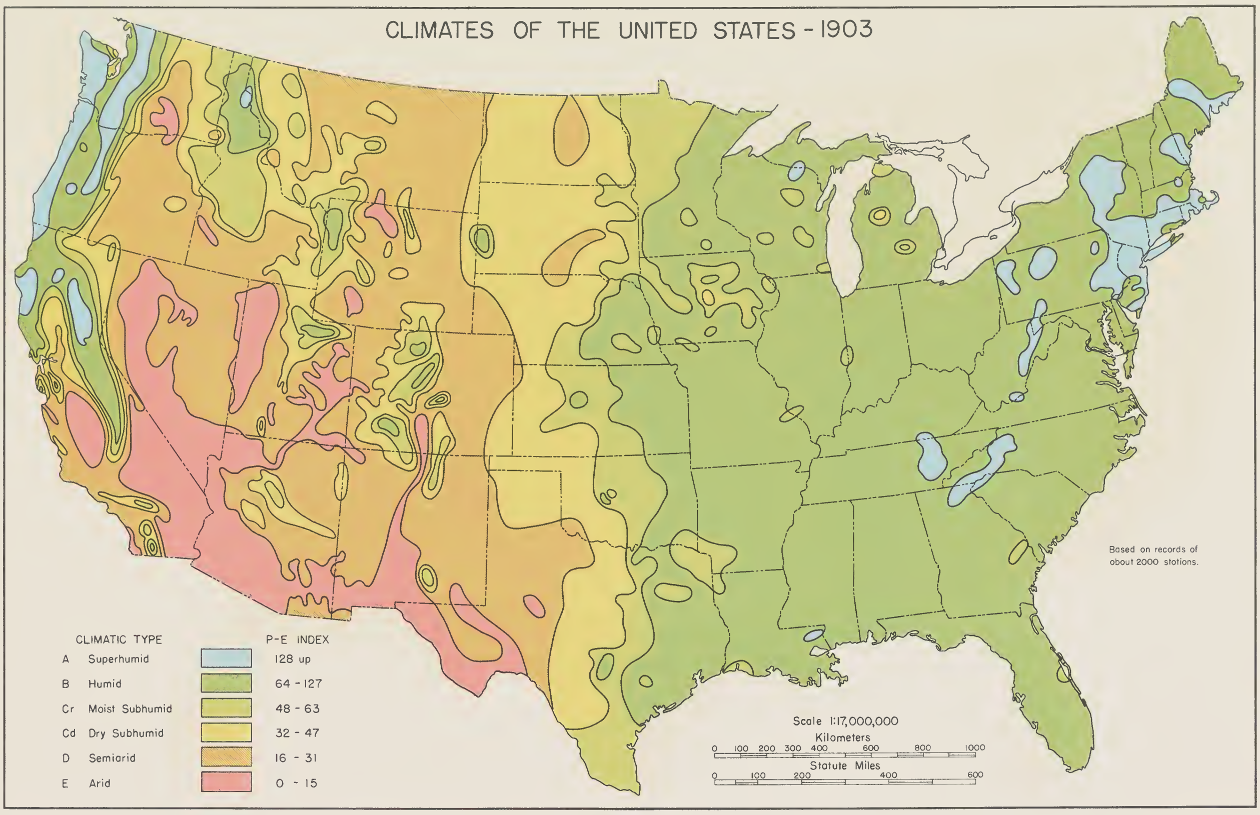
Plate 10


CLIMATES OF THE UNITED STATES - 1902

CROP SEASON (March through August)

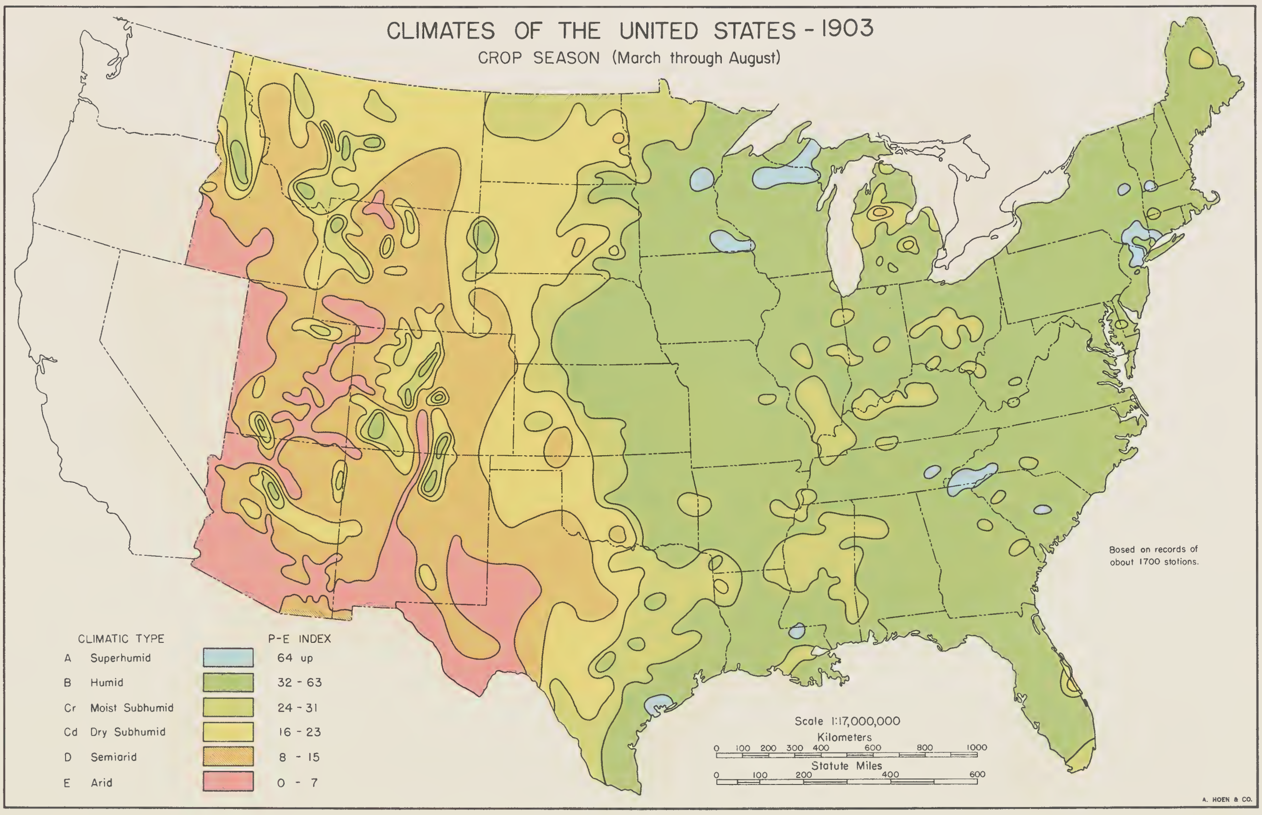
During the crop season of 1902, humid and moist-subhumid climates were shifted far westward in the central and northern part of the United States but were retracted along the Gulf coast to western Florida. A number of areas of subhumid climate appeared in the Ohio Valley and the Atlantic Coast States. A few small superhumid islands appeared in the humid region. A lobe of moist-subhumid climate extended from South Dakota through central Minnesota and upper Wisconsin to the southern shore of Lake Superior.

Plate 11



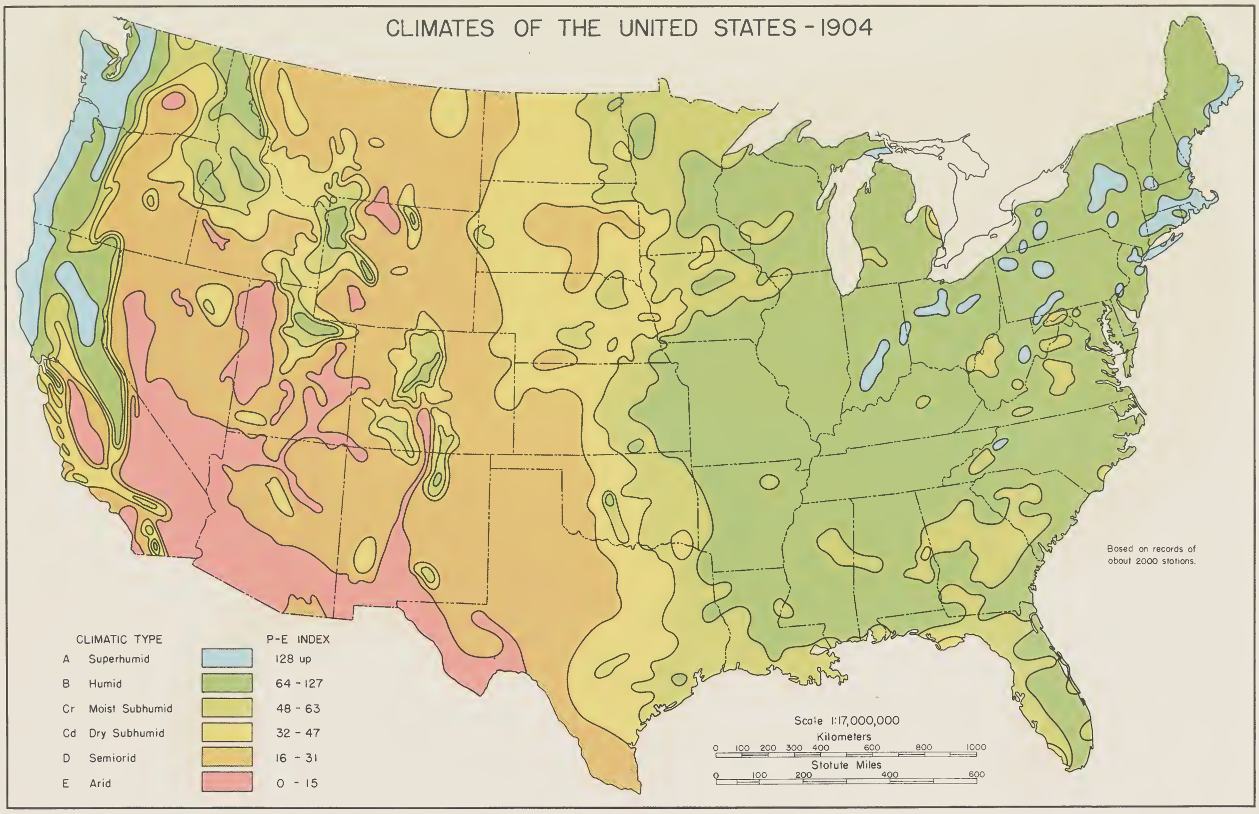
In 1903 distributions throughout much of the United States were strikingly similar to those of 1902. Humid climate again extended westward and the moist-subhumid belt was much narrowed. Semiarid areas appeared in central North Dakota and in central South Dakota. Subhumid islands were present in the humid area in eastern Nebraska, Iowa, Wisconsin, and lower Michigan. Superhumid areas were present in the Mississippi Delta and along the Appalachian axis from Georgia to New England. A small arid area appeared in west central Texas.

Plate 12



During the crop season of 1903 areas of subhumid climate in eastern United States were less numerous and smaller than in 1902. The arid area normally in the Pecos Valley was considerably expanded in west Texas and into southeastern New Mexico. The northern Great Plains, moist subhumid in 1902, were in 1903 dry subhumid. The moist-subhumid belt was narrower than usual and was displaced westward.

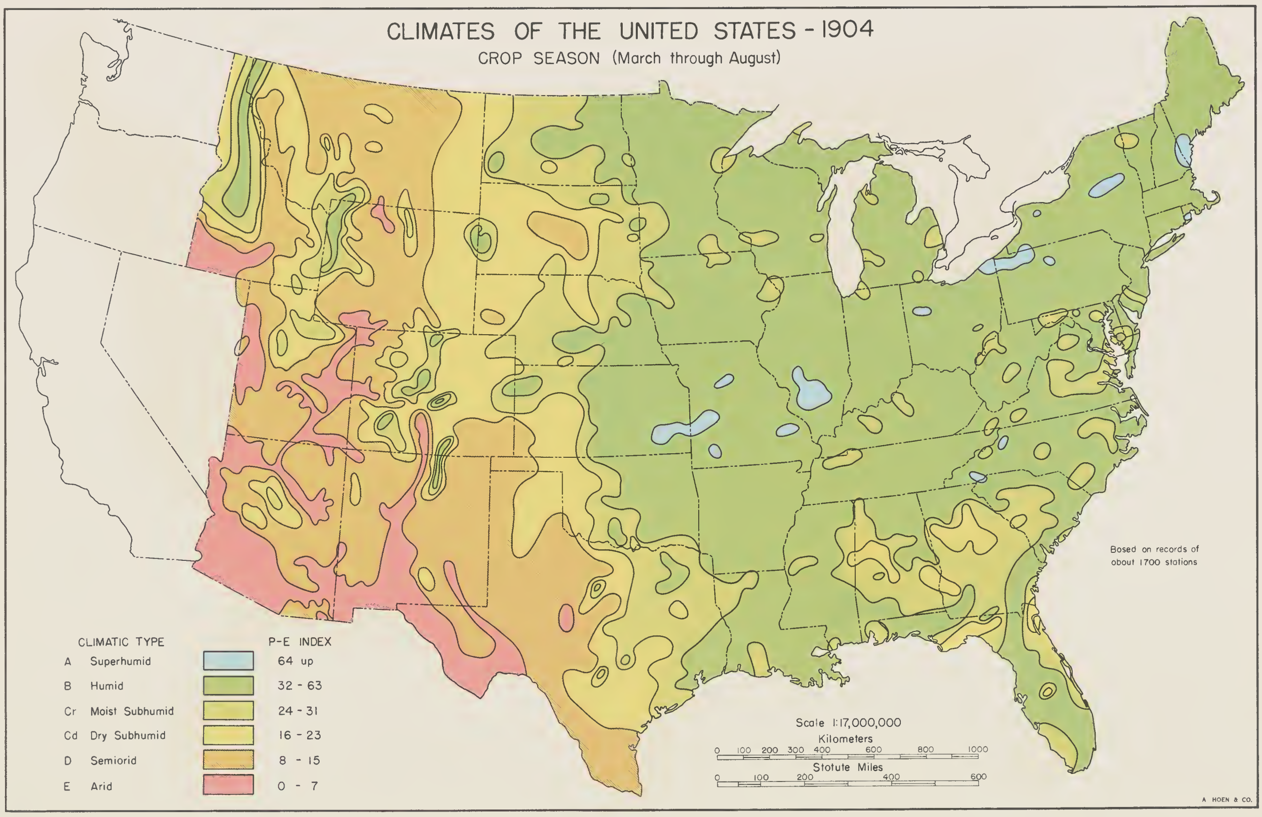
Plate 13



Based on records of about 2000 stations.

In 1904 superhumid islands appeared in the Ohio Valley and the Northeastern States and moist-subhumid islands in the Southeast. A rather large semiarid island appeared within the dry-subhumid area of South Dakota. Semiarid climate extended far east of its normal range in Oklahoma and Texas.

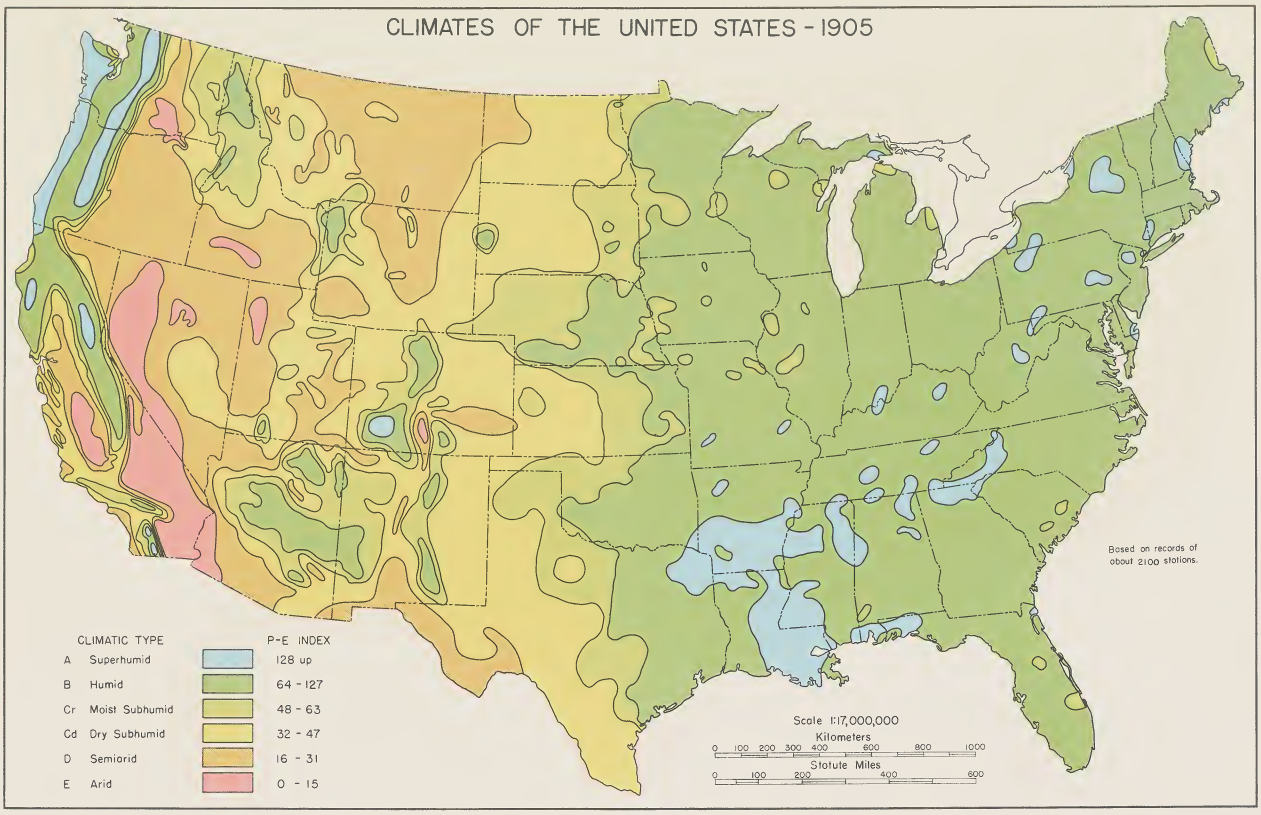
Plate 14



Based on records of about 1700 stations

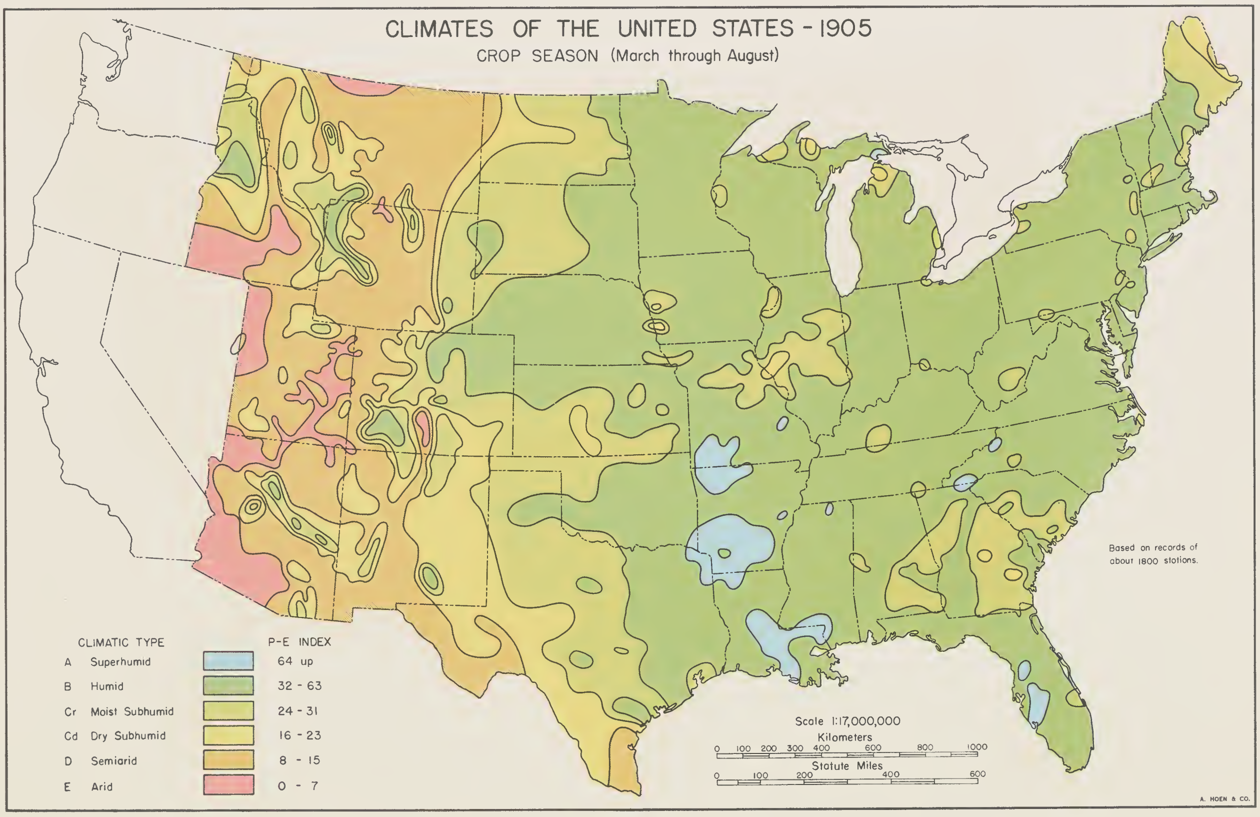
During the crop season of 1904, much of Alabama, Georgia, and South Carolina was either moist subhumid or dry subhumid. Humid climate was west of its normal position in Oklahoma, Kansas, Nebraska, and North Dakota. In Texas, much of the area ordinarily dry subhumid was semiarid, and a small arid island appeared in central Texas. A fairly large area in the center of South Dakota was semiarid.

Plate 15



The year 1905 was unusually moist throughout most of the country. Large areas of superhumid climate appeared in the lower Mississippi Valley and in the Tennessee Valley. Superhumid islands were less common than usual in New England. Humid climate was expanded far to the west in Oklahoma and Texas, and again in Iowa, Nebraska, and Minnesota. In the Great Plains semiarid climate, except for one small semiarid area in southeastern Colorado, was limited to Montana, northwestern North Dakota, and northern Wyoming. The arid areas in the West were greatly restricted. The parts of Arizona, New Mexico, and Texas ordinarily arid were semiarid. Humid and moist-subhumid climates were very extensive in Arizona and western New Mexico.

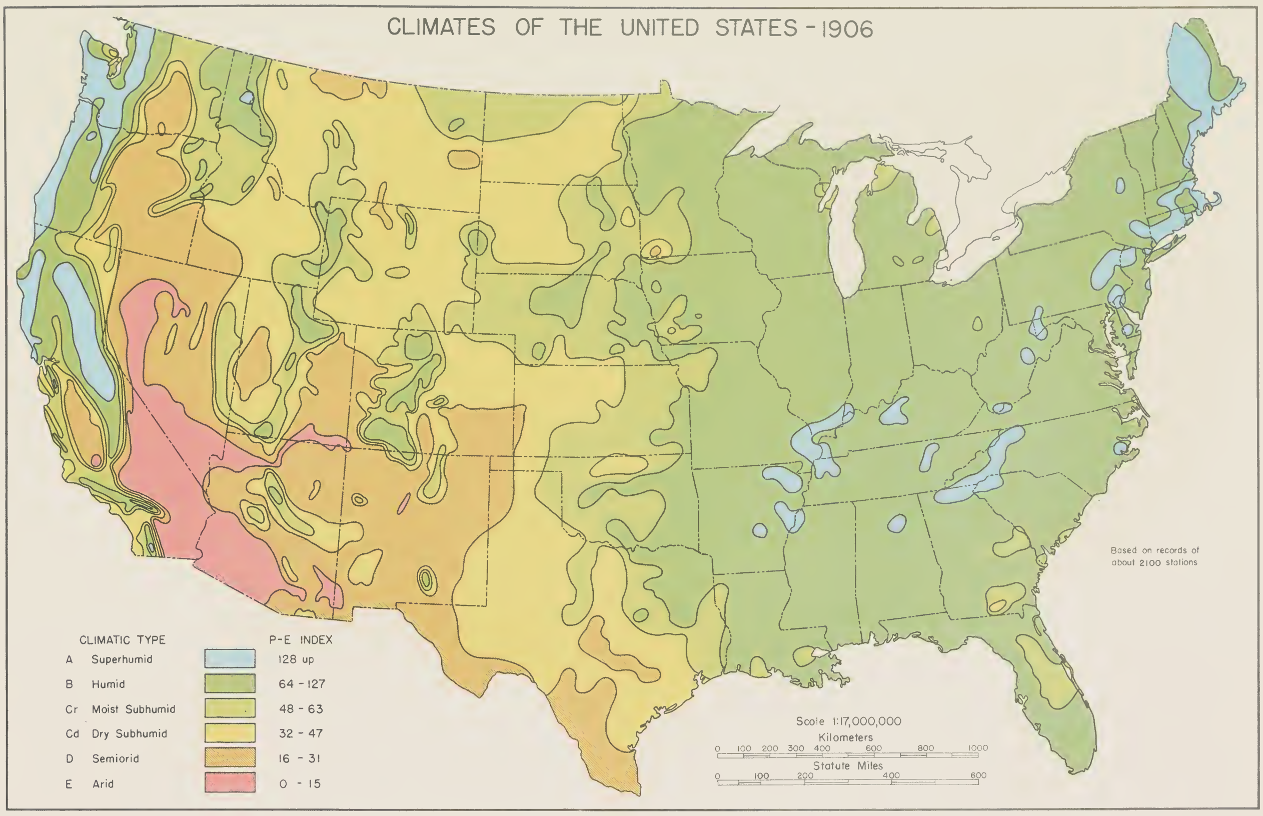
Plate 16



During the crop season of 1905, humid climate extended across Nebraska and northern Kansas into northeastern Colorado, and across Oklahoma into the Texas Panhandle. Superhumid climate was extensive in Missouri, Arkansas, and Louisiana. There were, however, small areas of subhumid climate that appeared in the eastern humid part of the United States. A small area in eastern Maine was semiarid. In the northern Great Plains the dry-subhumid belt was only a few miles wide, and moist-subhumid climate graded almost directly into semiarid. A small arid area appeared on the Canadian border in northern Montana.

Plate 17

CLIMATES OF THE UNITED STATES - 1906

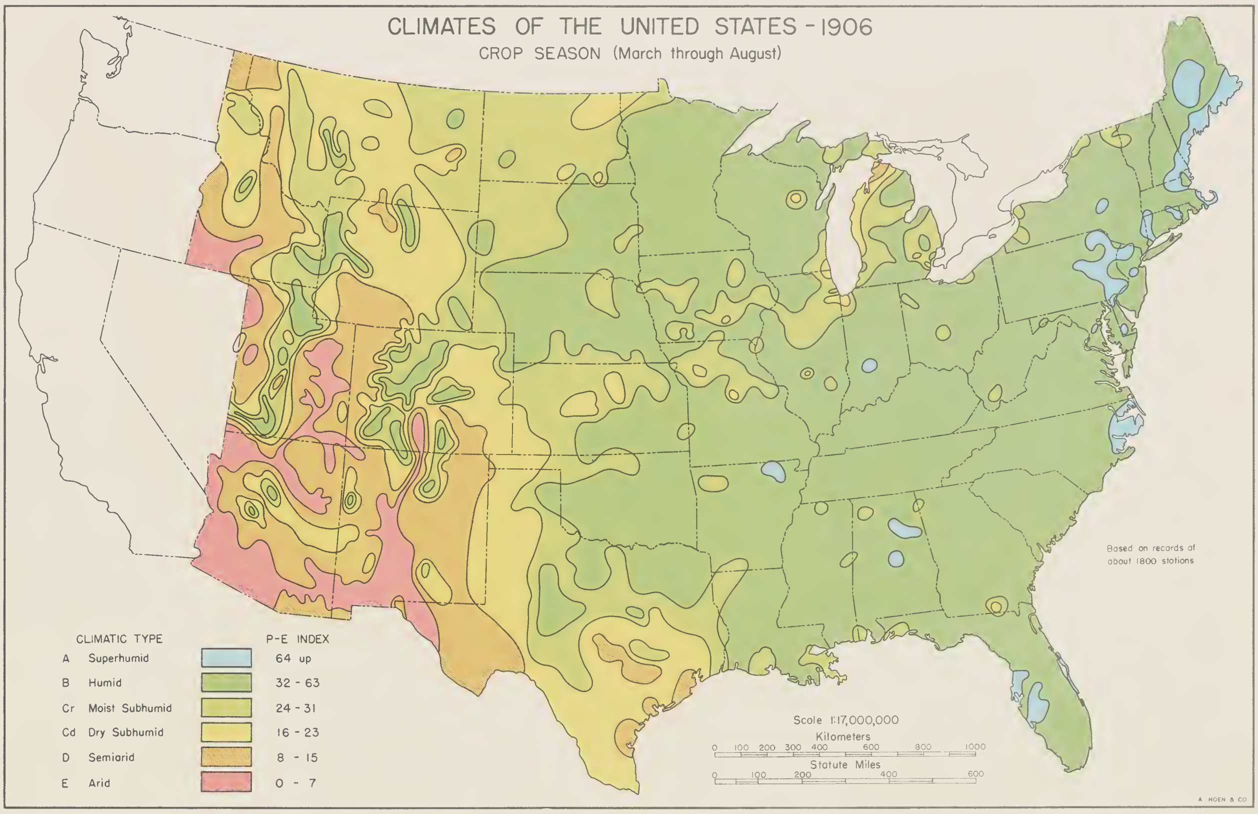


In 1906 most of the country was again more moist than usual. Semiarid climate had almost disappeared from the northern Great Plains. Moist-subhumid climate occupied much of North Dakota and South Dakota and most of Nebraska. Humid climate pushed west across most of Minnesota and across Iowa into Nebraska. The arid area was missing from eastern Washington and the one in the San Joaquin Valley in California was reduced to very small size. Most of the arid areas in Utah, Wyoming, Colorado, New Mexico, and Texas had disappeared, some being replaced by dry-subhumid areas.

Plate 18

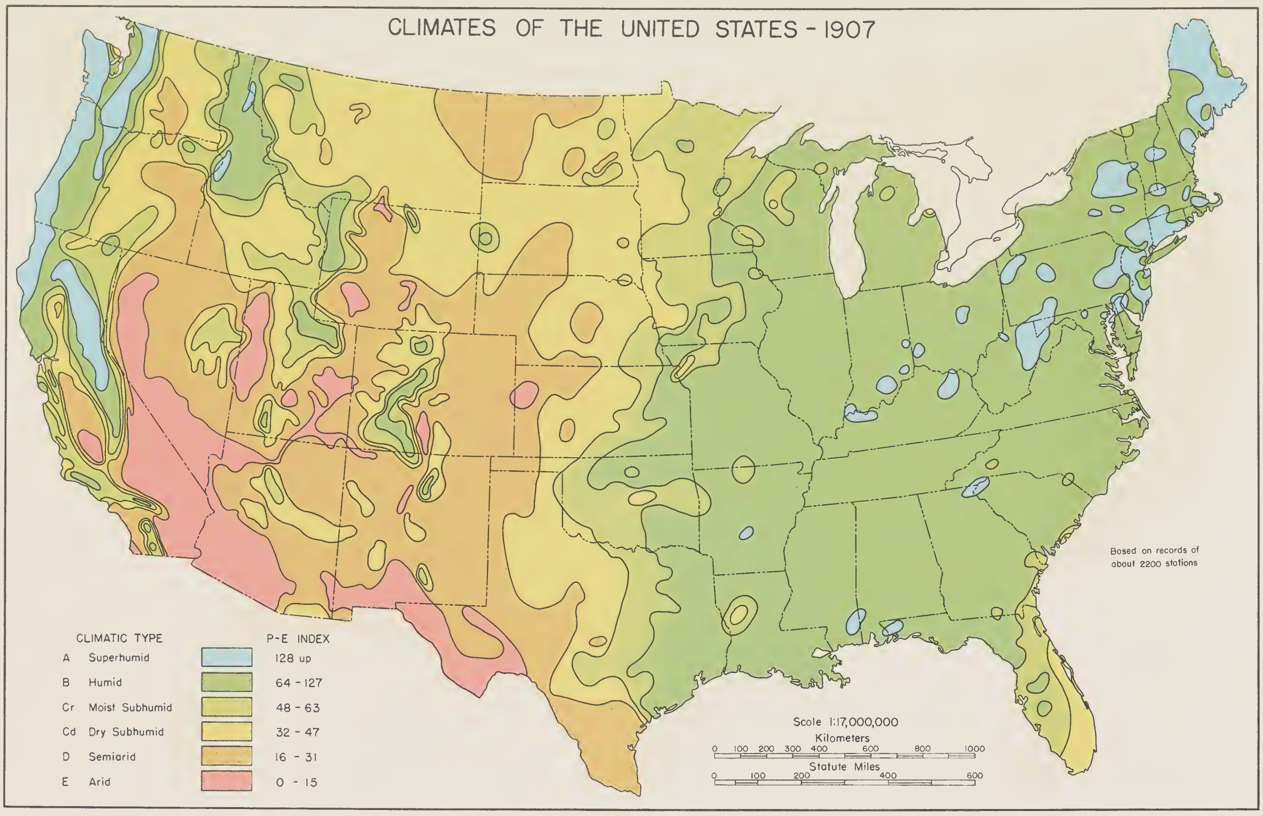
CLIMATES OF THE UNITED STATES - 1906

CROP SEASON (March through August)



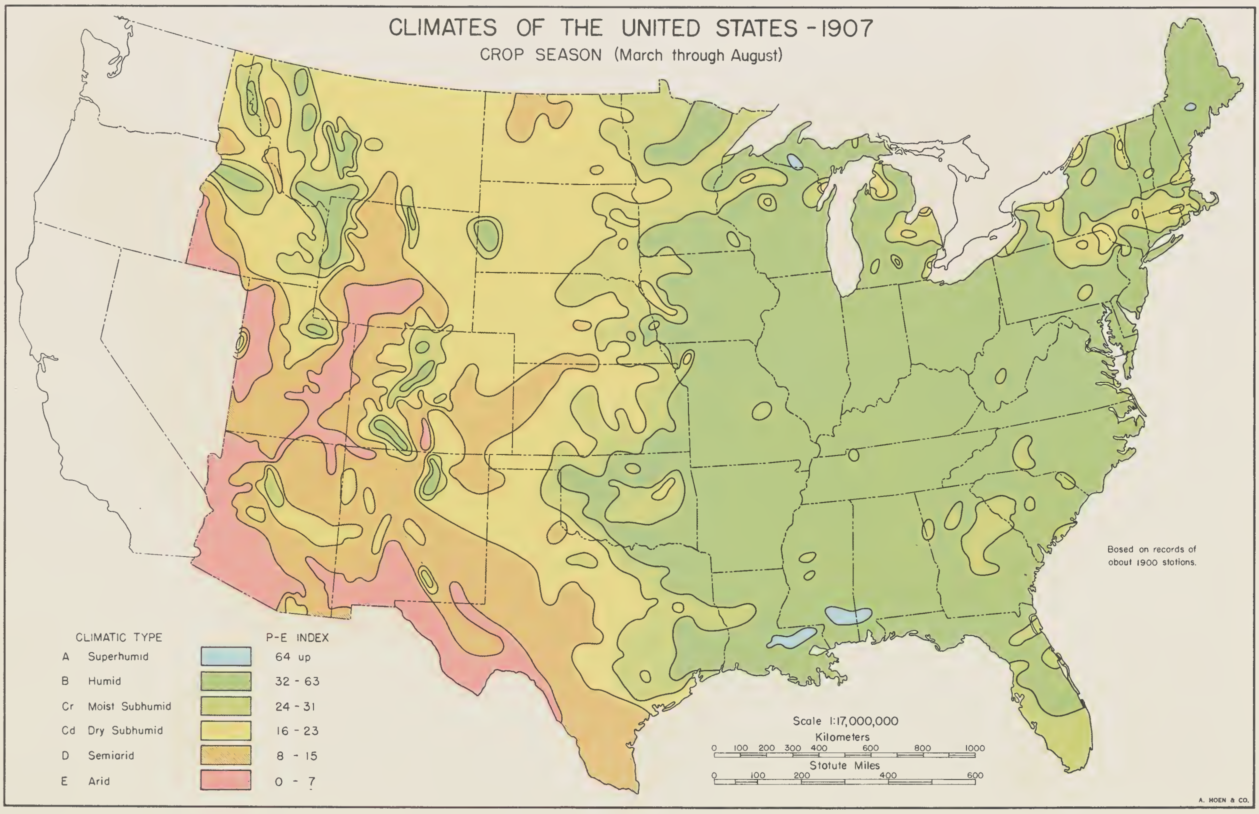
During the crop season of 1906 humid climate was extended far to the west. Large subhumid areas, however, appeared in a zone from Missouri through Michigan into northern New York. A small belt near the northern tip of the lower peninsula of Michigan was semiarid. There were also four small semiarid islands in southeast Texas. Several superhumid areas were present along the Atlantic coast from North Carolina to Maine. In Montana, North Dakota, and South Dakota, much of the area ordinarily dry subhumid was moist subhumid.

Plate 19



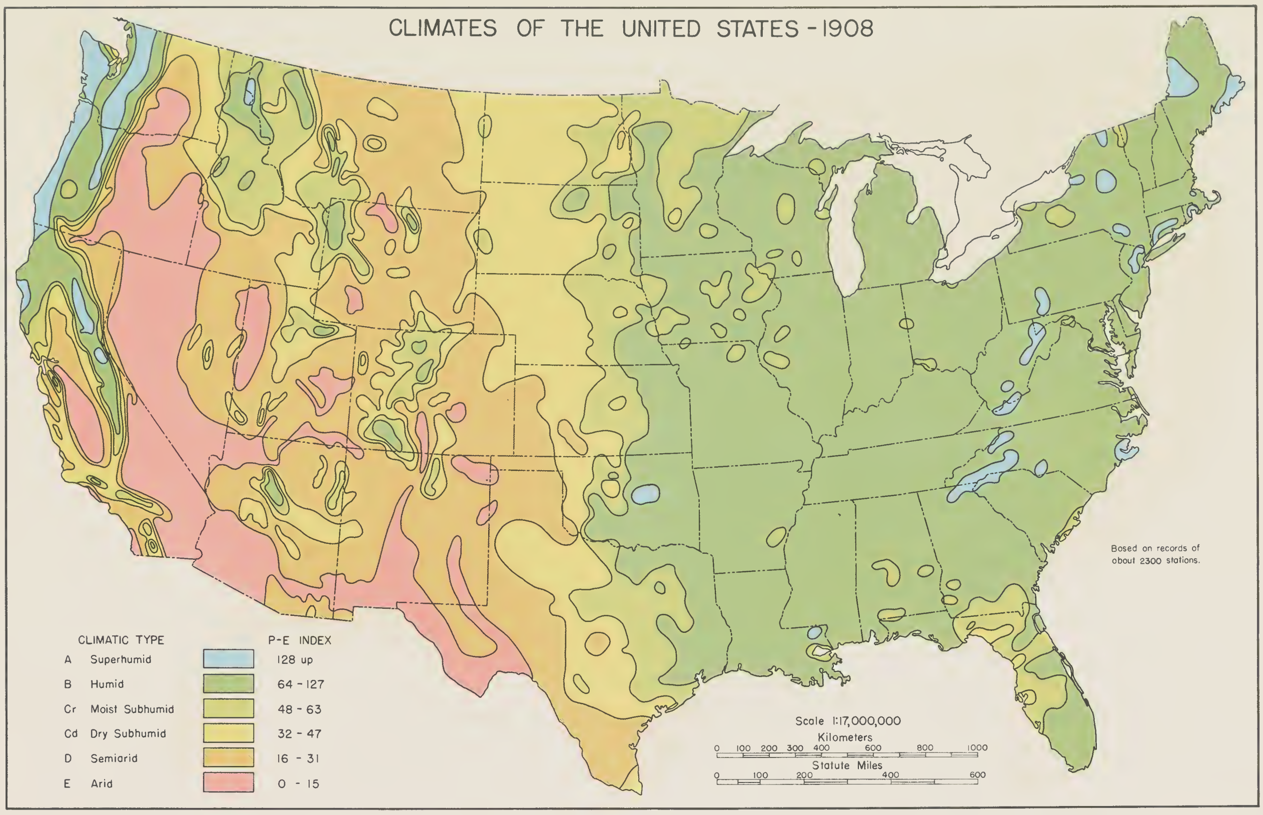
In 1907 the northern Great Plains were dry subhumid rather than semiarid. A small arid island appeared in western Kansas. In the Northeastern States and the Ohio Valley, there were several small superhumid areas. Most of Florida was subhumid, the Atlantic coastal portion being dry subhumid. The region west of the Rockies was more moist than usual. The arid area in eastern Washington disappeared and much of the semiarid lobe that ordinarily occupies eastern Oregon and extends into eastern Washington became dry subhumid. Much of the area in Idaho ordinarily dry subhumid and semiarid was humid and moist subhumid.

Plate 20



During the crop season of 1907 no unusual climatic displacements occurred. The moist-subhumid belt extending from Texas to Minnesota was very irregular and much narrower than usual and was moved farther east in North Dakota, South Dakota, and Nebraska. A humid lobe occupied much of Oklahoma. A few small subhumid islands appeared in the Eastern States. Idaho and Montana were considerably moister than usual.

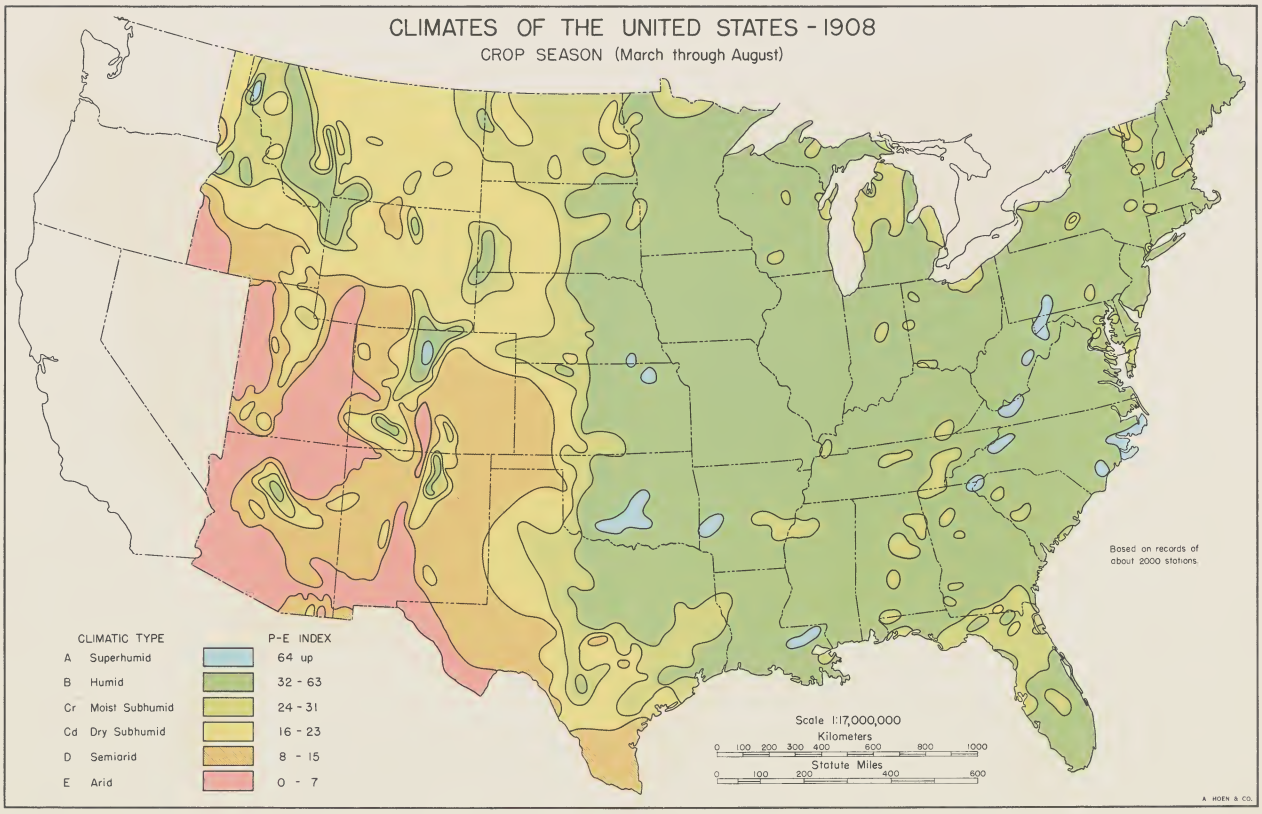
Plate 21



CLIMATES OF THE UNITED STATES - 1908

In 1908 the arid area in the Western States was much expanded. At the same time the humid area was extended in central United States to include considerably more of Oklahoma and Kansas than usual and to take in a part of Nebraska, most of Iowa, and the southern part of Minnesota. Four small, arid islands appeared in eastern Colorado, northeastern New Mexico, and the Texas Panhandle. Three small, dry-subhumid areas appeared along the Gulf coast of Florida.

Plate 22

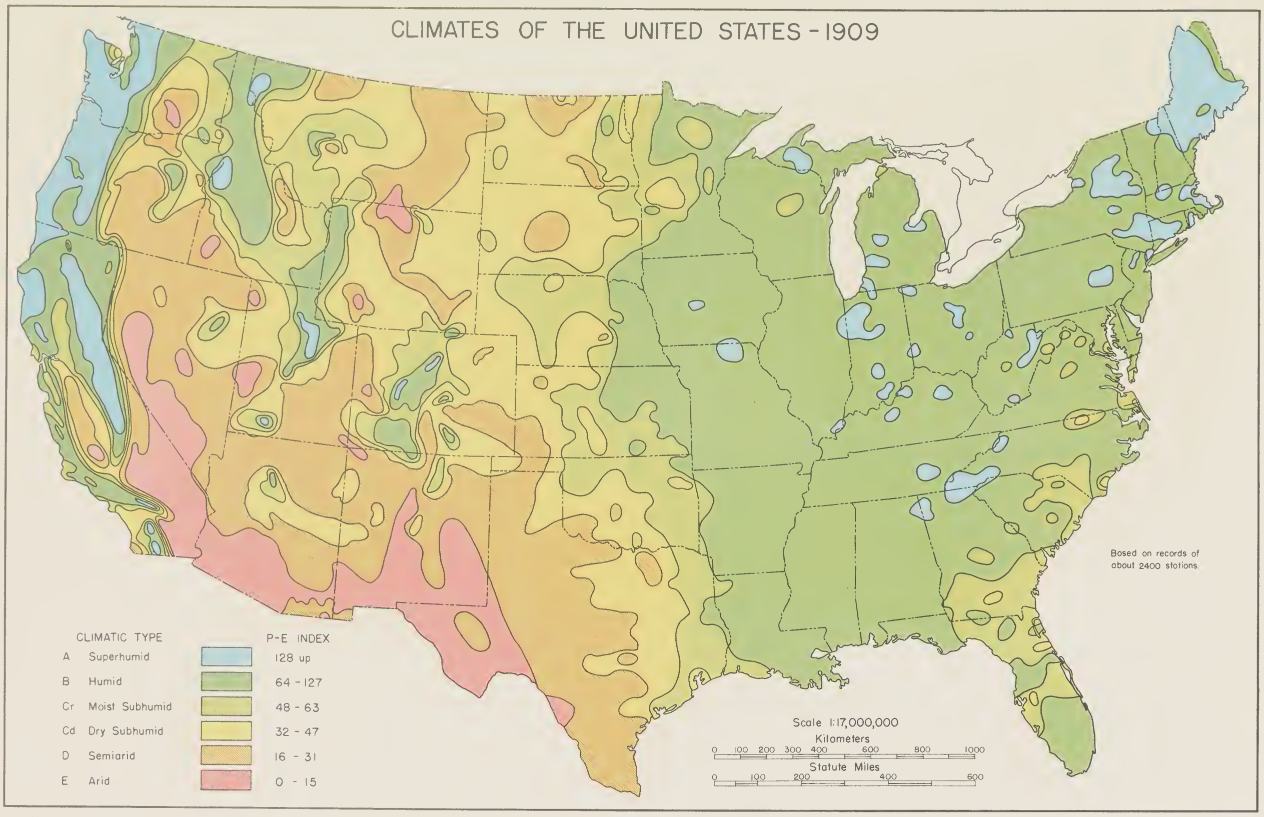


CLIMATES OF THE UNITED STATES - 1908

CROP SEASON (March through August)

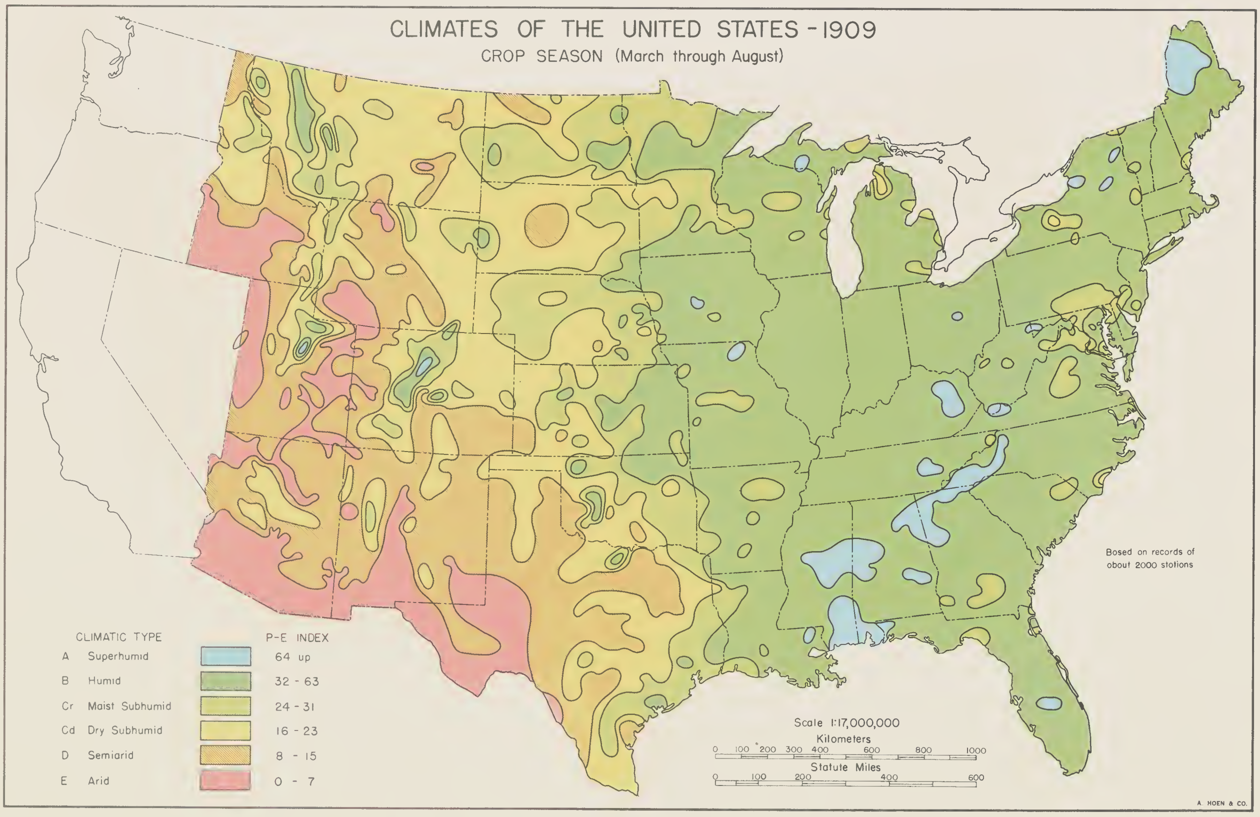
During the crop season of 1908, the eastern humid area extended westward to include most of the region ordinarily moist subhumid and into the dry-subhumid belt in central Texas. Within the humid region were scattered moist-subhumid and superhumid islands. In western Montana humid climate displaced dry subhumid. The arid island in the Big Horn Basin of Wyoming disappeared.

Plate 23



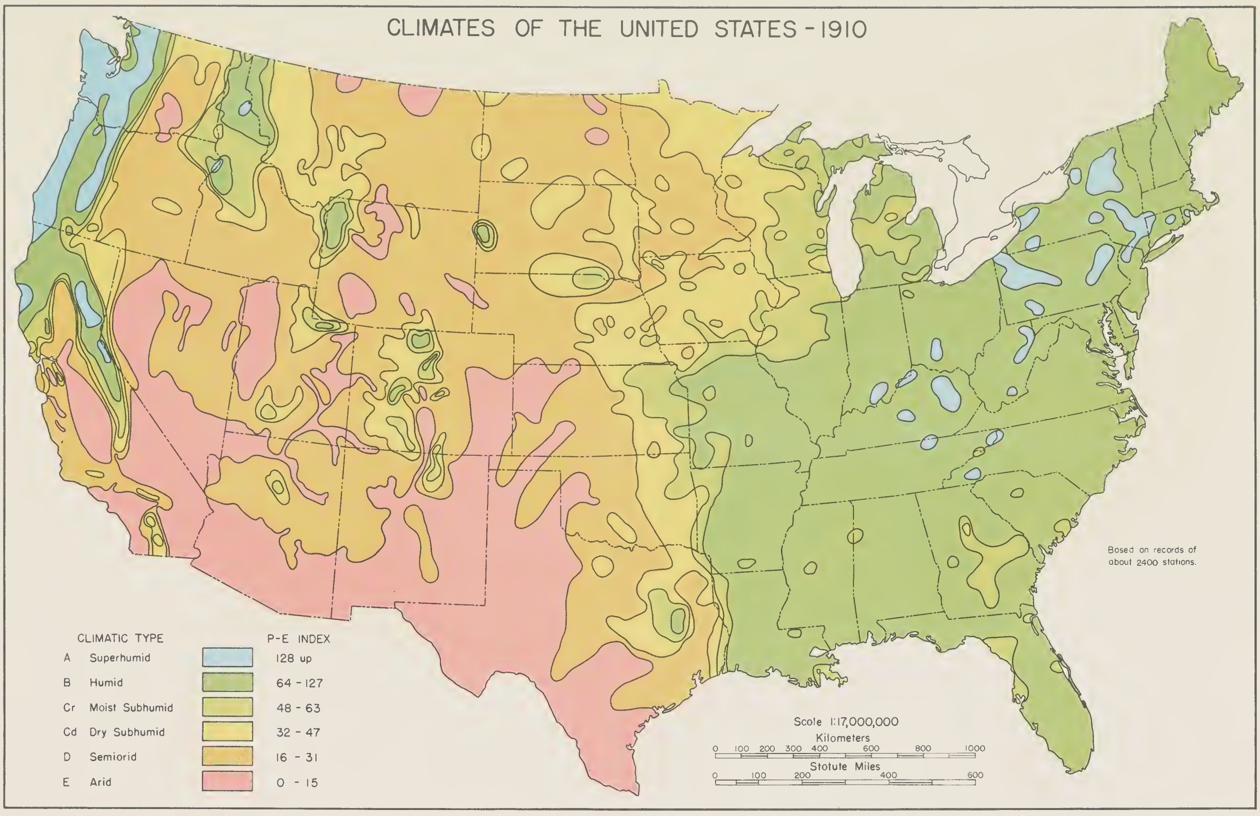
In 1909 superhumid areas were again extensive in the Northeast, occurring as far west as Michigan and Iowa, and as far south as Georgia and Alabama. Iowa, eastern Nebraska, southeastern Minnesota, and northeastern Kansas were humid. At the same time, the coastal areas of the Carolinas and Georgia were subhumid. In the south-central part of the country, the climatic zones were displaced eastward and the desert area was considerably expanded in New Mexico and west Texas.

Plate 24



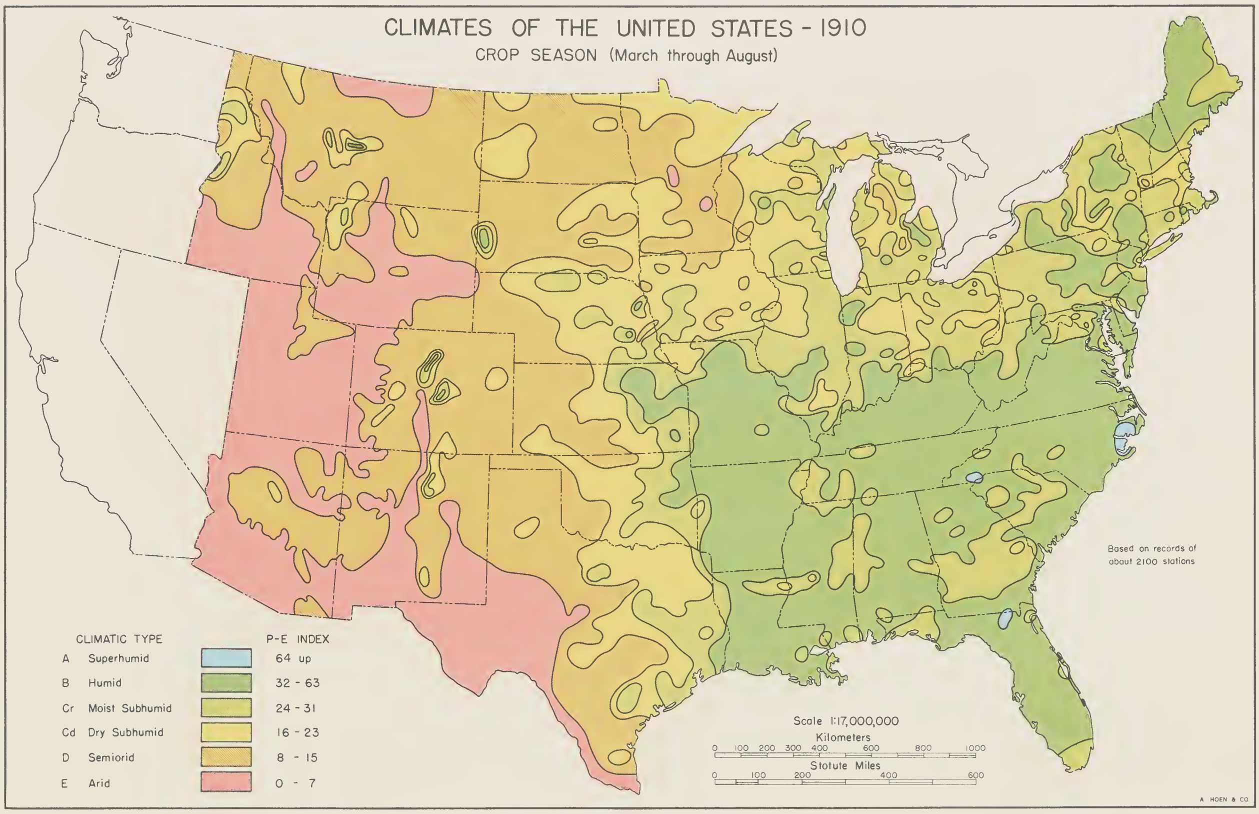
During the crop season of 1909, superhumid areas were extensive east of the Mississippi and south of the Ohio. In the Middle West, there was unusually great local variation in climate, the two subhumid and the semiarid belts being extremely irregular and being interspersed with many small islands of different climate. Thus, as in Oklahoma, areas with peculiarly favorable climate were adjacent to areas of serious drought.

Plate 25


CLIMATES OF THE UNITED STATES - 1910

In 1910 the arid and semiarid climates were greatly expanded, the arid climate extending into central and east Texas, eastern New Mexico, and western Oklahoma, and into eastern Colorado and western Kansas. Other arid areas appeared in northern Montana, eastern North Dakota, and in Wyoming and Nebraska. Semiarid climate was displaced eastward in Texas, Oklahoma, Kansas, and Nebraska, and far eastward in the northern part of the country across Minnesota into Wisconsin. In spite of the great extension of arid and semiarid climates, the eastern part of the country was wetter than usual, with a number of superhumid islands appearing in the Ohio Valley and the North Atlantic States.

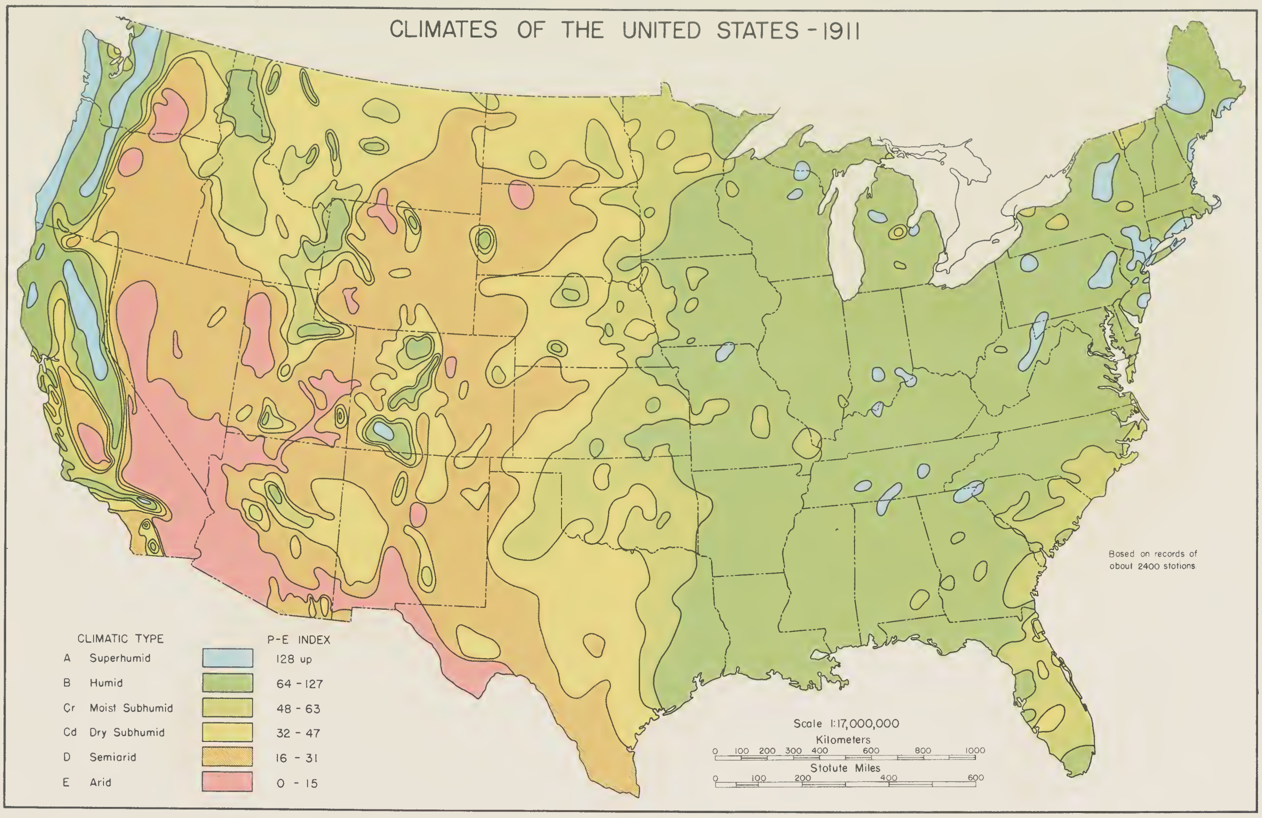
Plate 26


CLIMATES OF THE UNITED STATES - 1910

CROP SEASON (March through August)

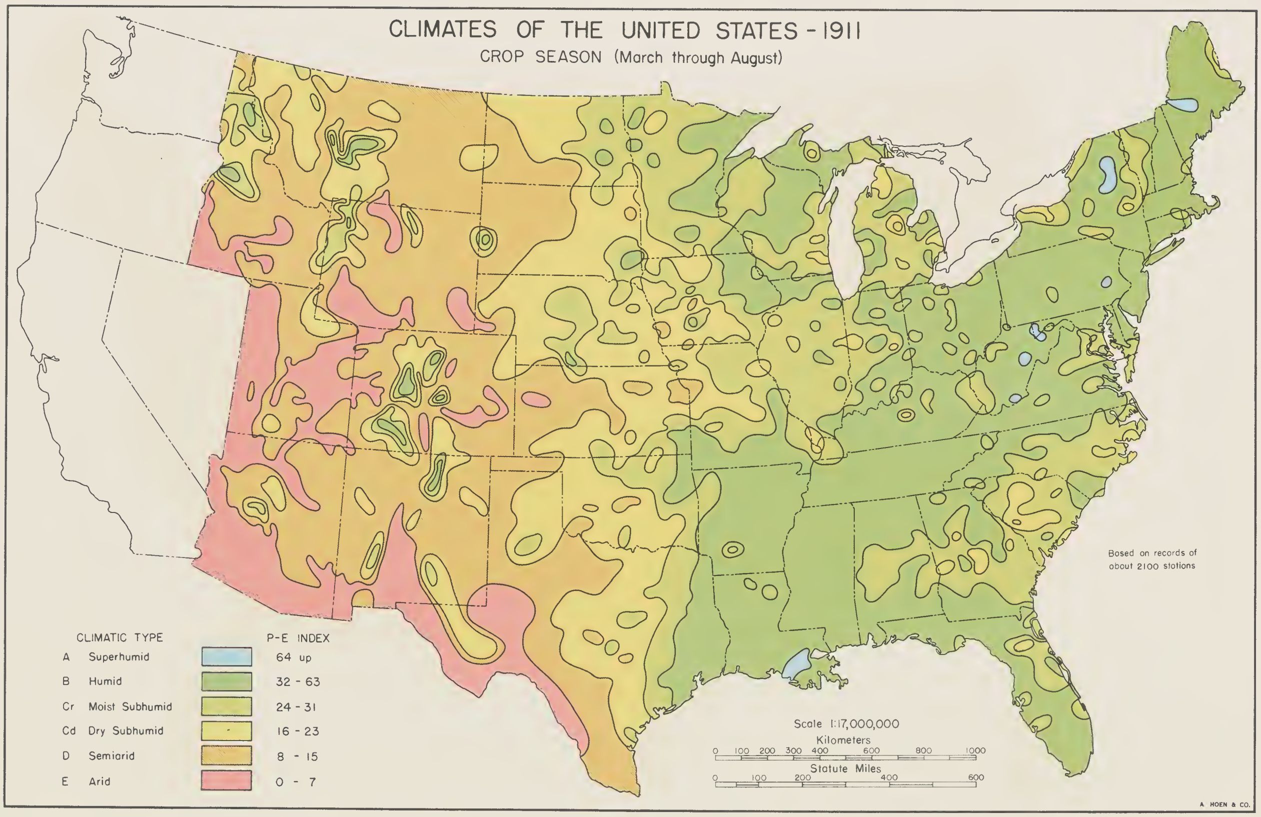
In the crop season of 1910 virtually the entire United States was drier than usual. Particularly spotty were the distributions of climate in the northern half of the country east of the Mississippi. The two subhumid belts were very irregular and in the North extended eastward to the Atlantic. Two small arid islands appeared in Minnesota. Several small semiarid islands were present in Iowa, Wisconsin, and Michigan, and one in southern Vermont.

Plate 27



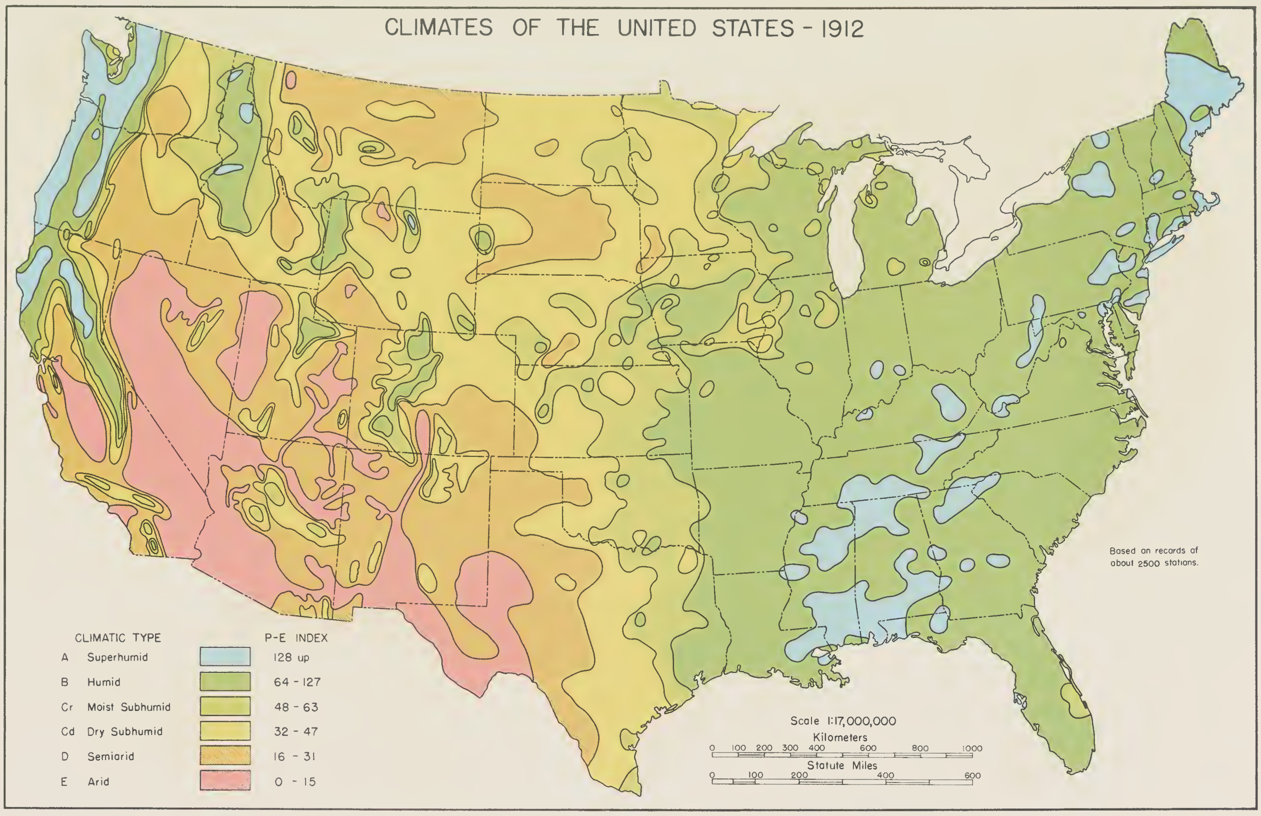
In 1911 there was a tendency for the subhumid belts running north and south through the interior of the country to be more irregular than usual. Moist-subhumid climate extended eastward into the humid areas of Arkansas and Missouri, and at the same time far westward into the Texas Panhandle. Much of Montana east of the mountains and most of North Dakota were dry subhumid. The arid area in eastern Washington was considerably enlarged and another arid area appeared in central Oregon. Small arid areas also appeared in western South Dakota and eastern Colorado. The South Atlantic coast and Florida were moist subhumid.

Plate 28



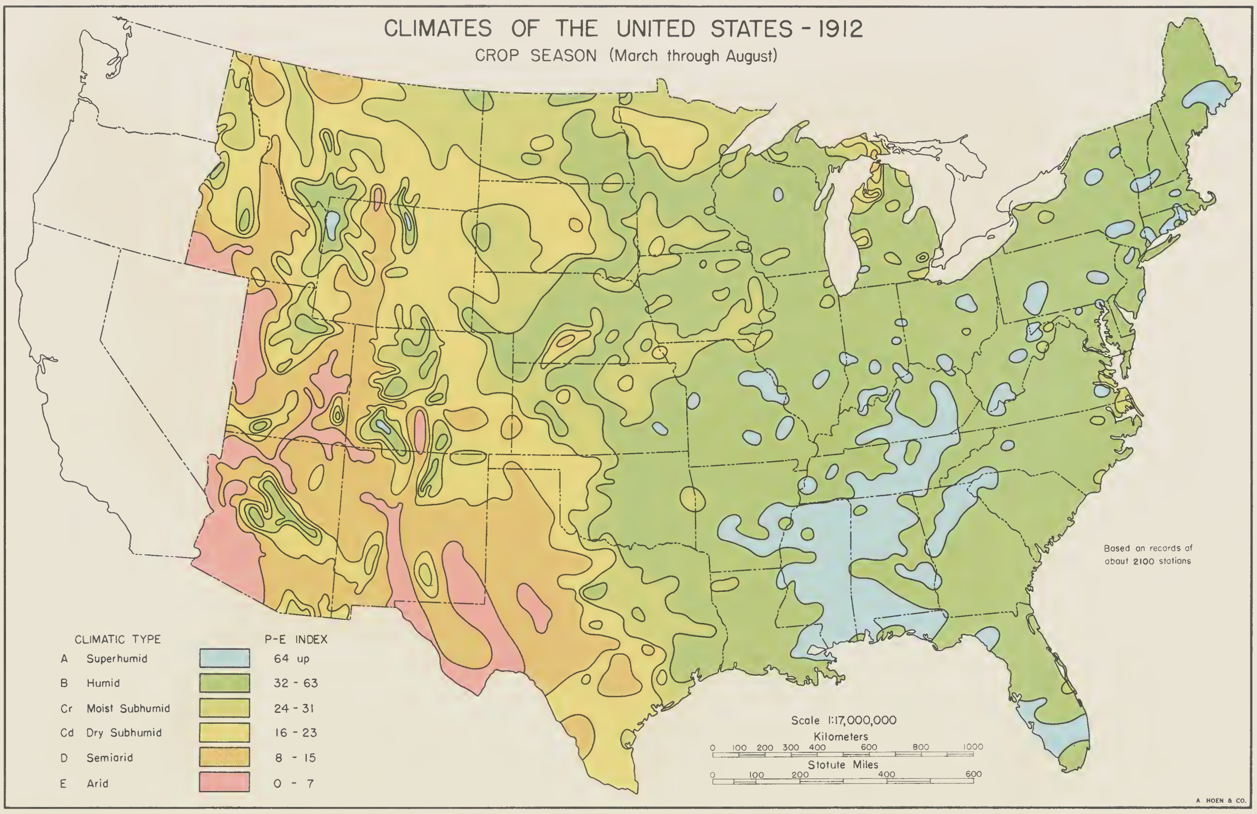
During the crop season of 1911, as in 1910, the climatic distribution was unusually spotty. In each of the climatic belts many small areas of moister and drier climate appeared. The Lake States, the Corn Belt, and the South Atlantic States were largely subhumid. Small arid areas appeared in western Kansas, eastern Wyoming, and eastern Colorado. The arid area in west Texas was considerably expanded.

Plate 29



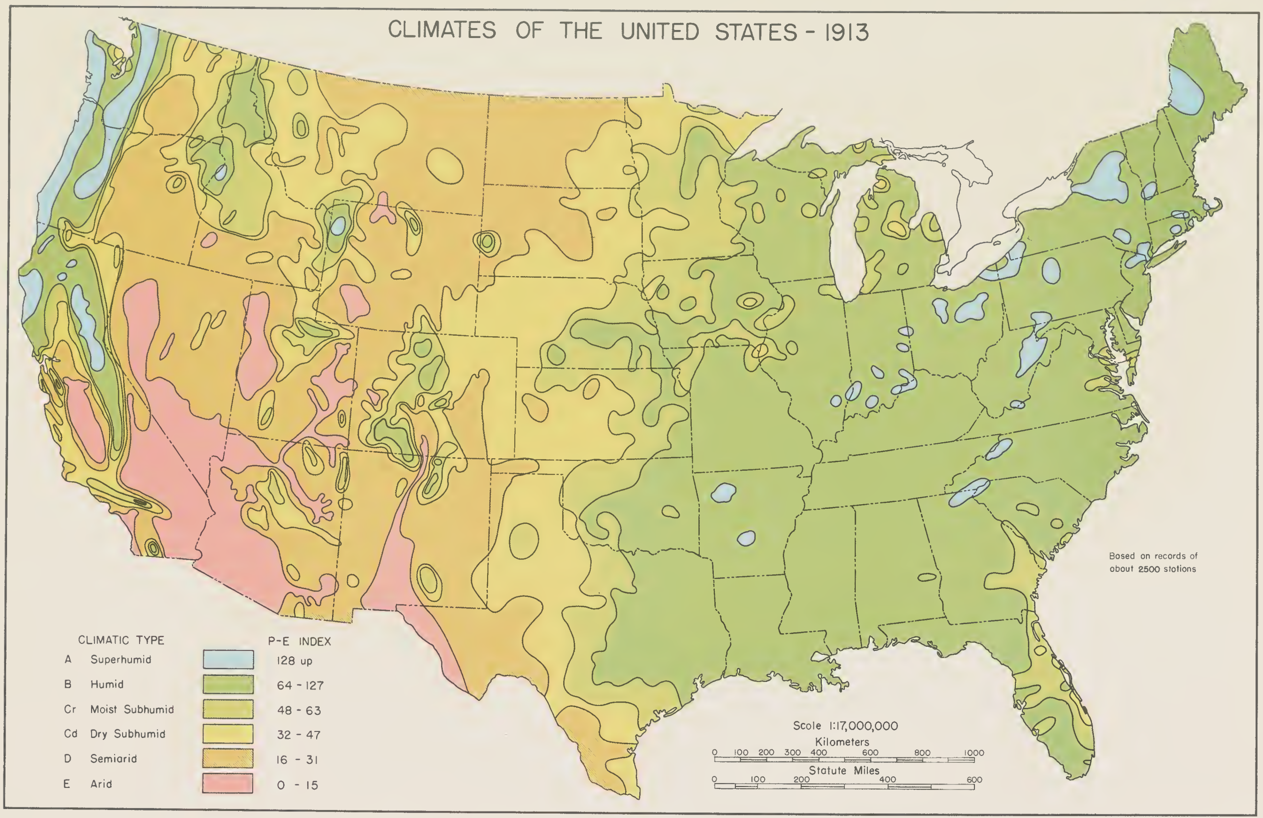
In 1912 superhumid climate was extensive in the States east of the Mississippi and south of the Ohio, as well as in New England and the North Atlantic States. The moist-subhumid belt was very irregular and moved eastward in Minnesota. Most of the northern Plains normally semiarid were dry subhumid. A large area in South Dakota, normally dry subhumid, however, dropped to semiarid. Arid climate in the Southwest was somewhat more extensive than usual, but the arid area in eastern Washington had disappeared. Most of Idaho was moister than usual.

Plate 30



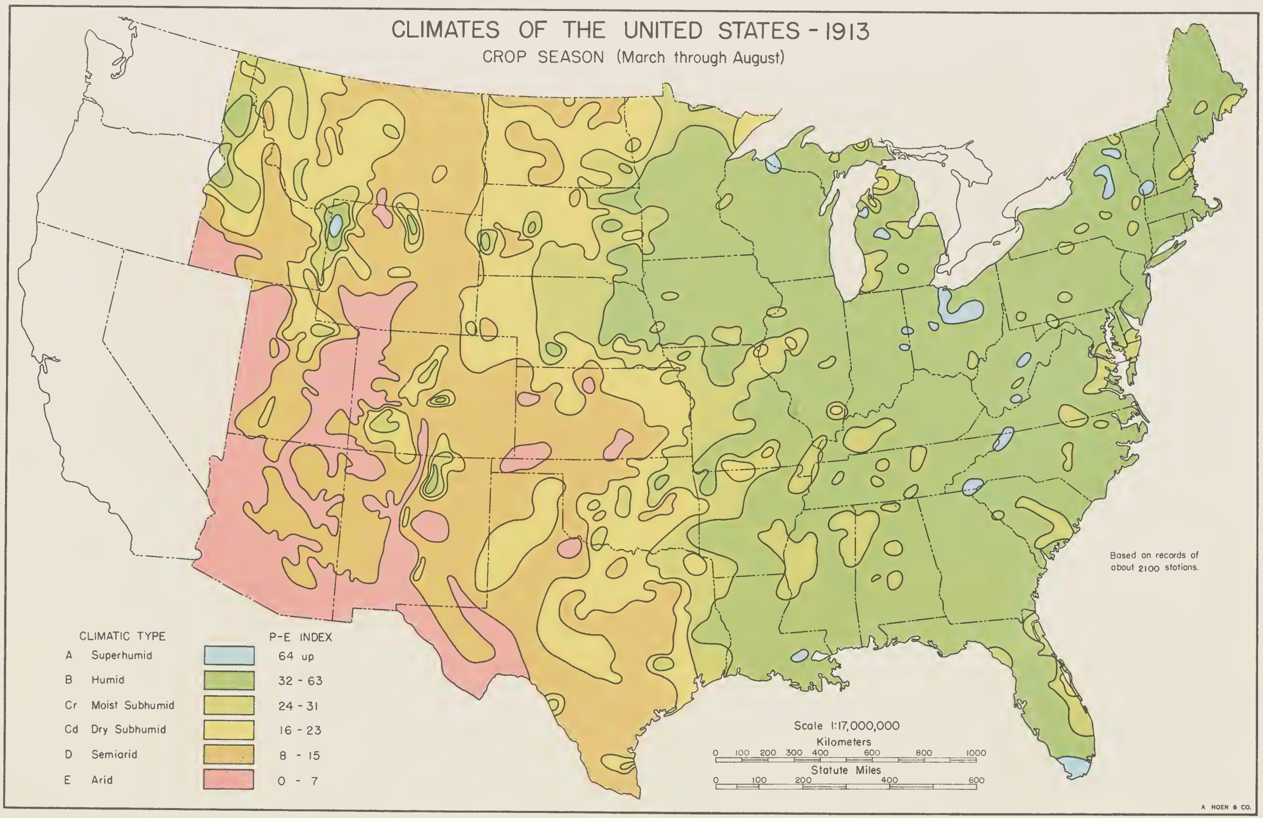
During the crop season of 1912, nearly every State normally humid had some superhumid areas, and Mississippi, Alabama, and much of Tennessee and Kentucky were largely superhumid. Humid and moist-subhumid climates extended far west of their normal range in the North Central States. A large dry-subhumid area appeared in northern Minnesota, however, and several small semiarid areas in both peninsulas of Michigan. Much of west Texas and southeastern New Mexico was arid.

Plate 31

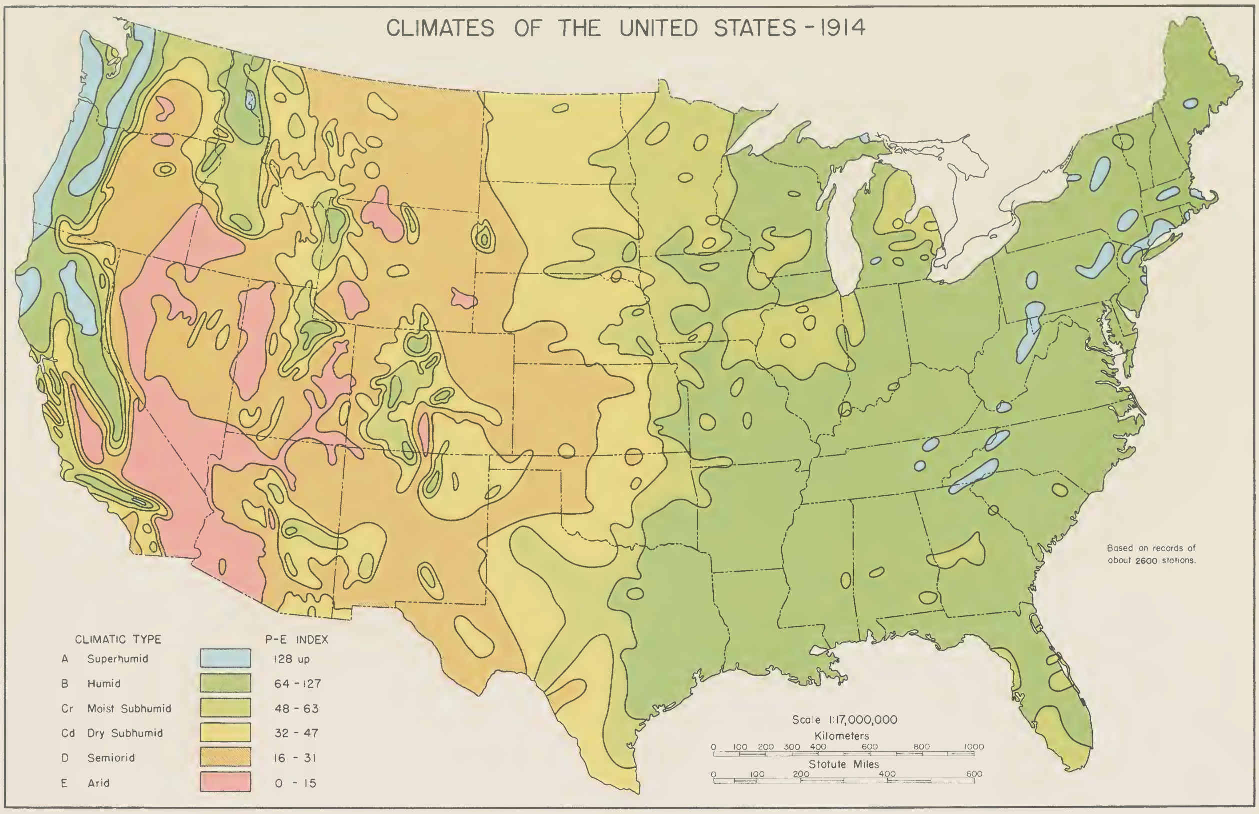


In 1913 the semiarid climate extended a little to the east in the Dakotas but was displaced by dry-subhumid climate in the central Great Plains. Humid climate pushed westward into central Oklahoma and central Texas. Throughout its entire extent the moist-subhumid belt was irregular and considerably narrower than usual. Areas of superhumid climate appeared along an axis from Arkansas to New England. The arid area in eastern Washington had disappeared. There was, however, a small island of arid climate in southern Idaho.

Plate 32

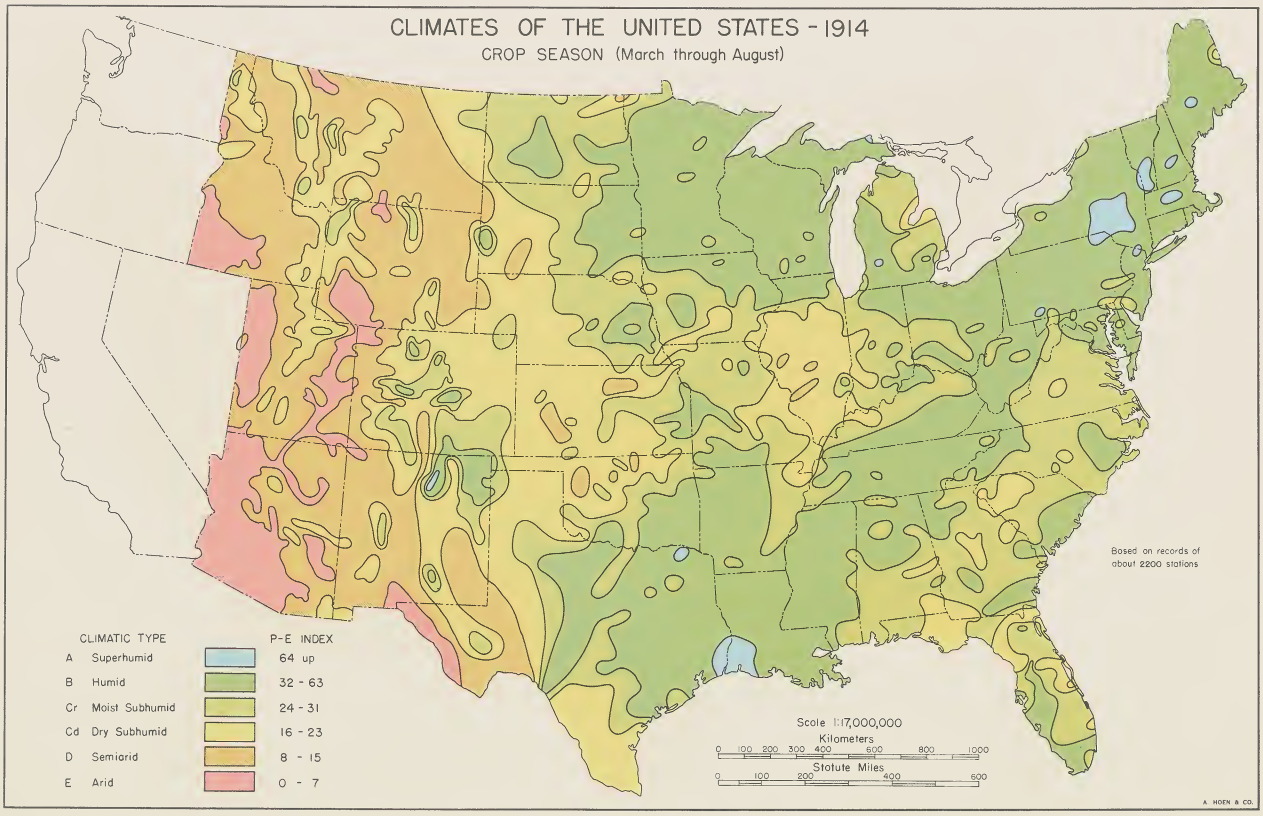


During the crop season of 1913, the climatic belts were very irregular and the semiarid area was considerably expanded. Kansas, Oklahoma, and north Texas were drier than usual and several small areas of arid climate appeared in these States. Small subhumid islands dotted the humid region throughout the East. A few superhumid areas also appeared.



CLIMATES OF THE UNITED STATES - 1914

In 1914 the subhumid climatic belts were considerably wider than usual in the northern prairie and Plains States. South of Nebraska, however, they were abnormally narrow and were displaced eastward in Kansas and Oklahoma, and far westward in Texas. Humid climate extended westward into central Texas. Three rather large subhumid areas appeared in Wisconsin, Illinois, and lower Michigan. A small arid area appeared in eastern Wyoming. Southwestern Idaho and southeastern Oregon were arid.

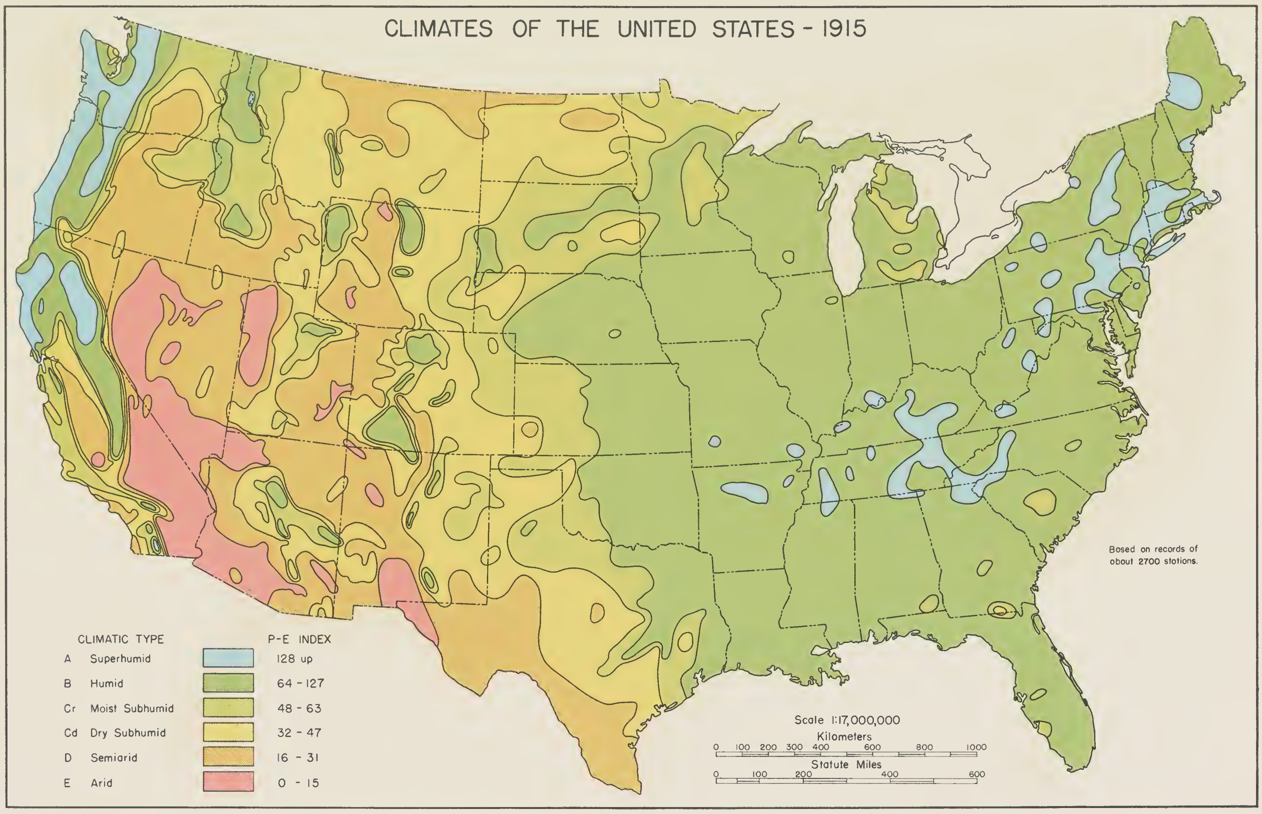


CLIMATES OF THE UNITED STATES - 1914

CROP SEASON (March through August)

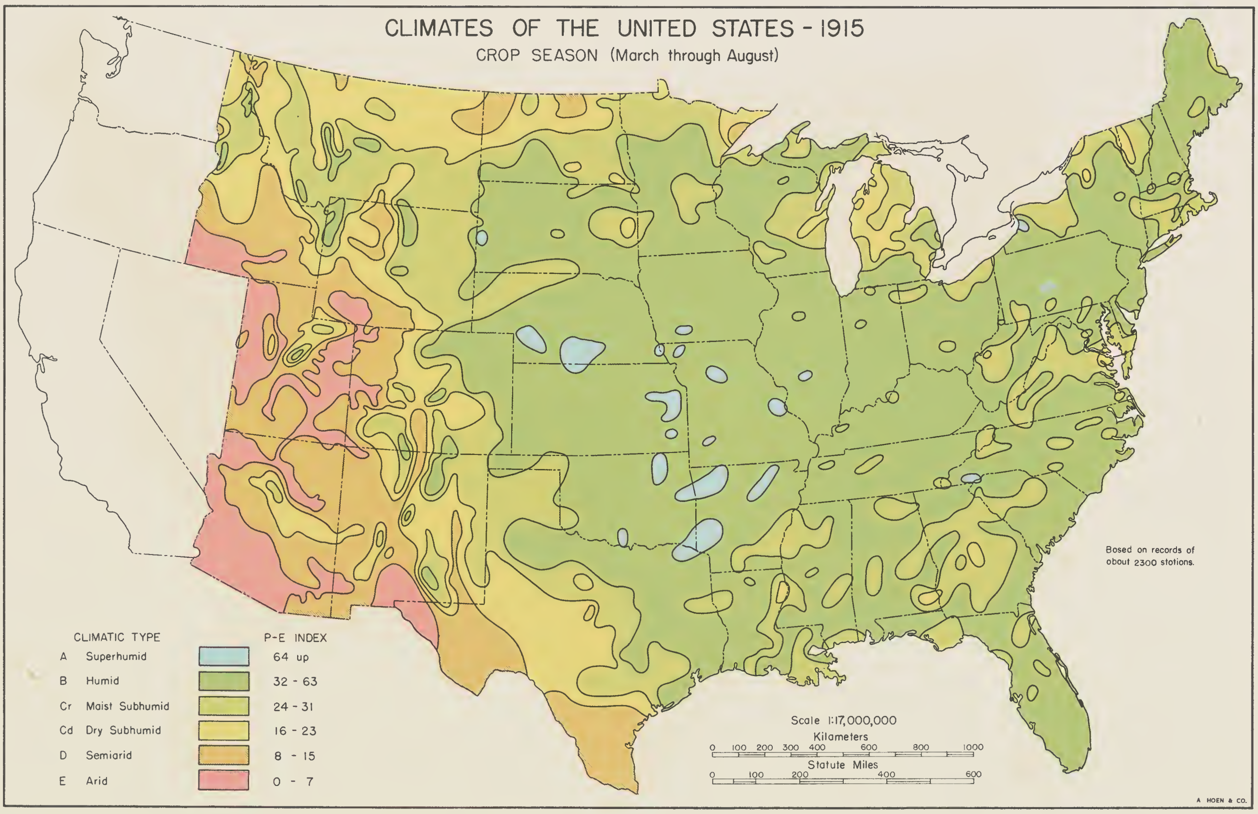
During the crop season of 1914, dry-subhumid climate with semiarid islands brought serious drought to Illinois and parts of the adjoining States. In the Southeastern States from Virginia to Mississippi moist subhumid and dry-subhumid climates were extensive. Humid climate, on the other hand, extended far west into Texas and into the Dakotas. Two small islands of superhumid climate appeared in east Texas and southern Louisiana; others in New England, New York, and Pennsylvania. A small arid area appeared in northern Montana. The arid area in Texas, New Mexico, and the Southwest was considerably contracted.

Plate 35



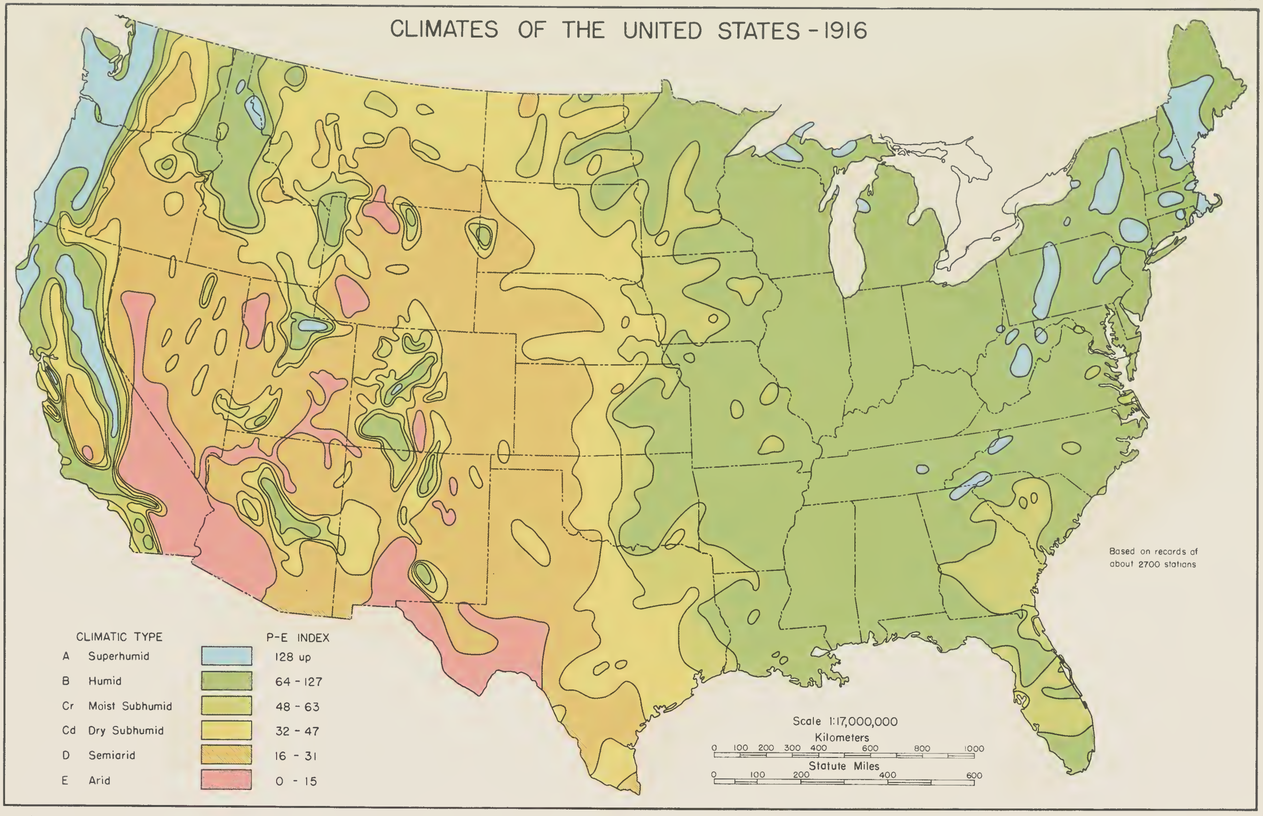
In 1915 most of the United States was more moist than usual. Numerous small islands of superhumid climate dotted the lower Mississippi and Ohio Valleys and the Northeastern States. Humid climate extended far west except in North Dakota, and a lobe extended across Nebraska into northeastern Colorado. Except in the northern parts of North Dakota and Montana semiarid climate was altogether missing from the Great Plains. A considerable part of the Great Plains was moist subhumid and a small area in the Texas Panhandle was humid. The arid area usually present in eastern Washington was missing, and that in the San Joaquin Valley in California was greatly restricted.

Plate 36



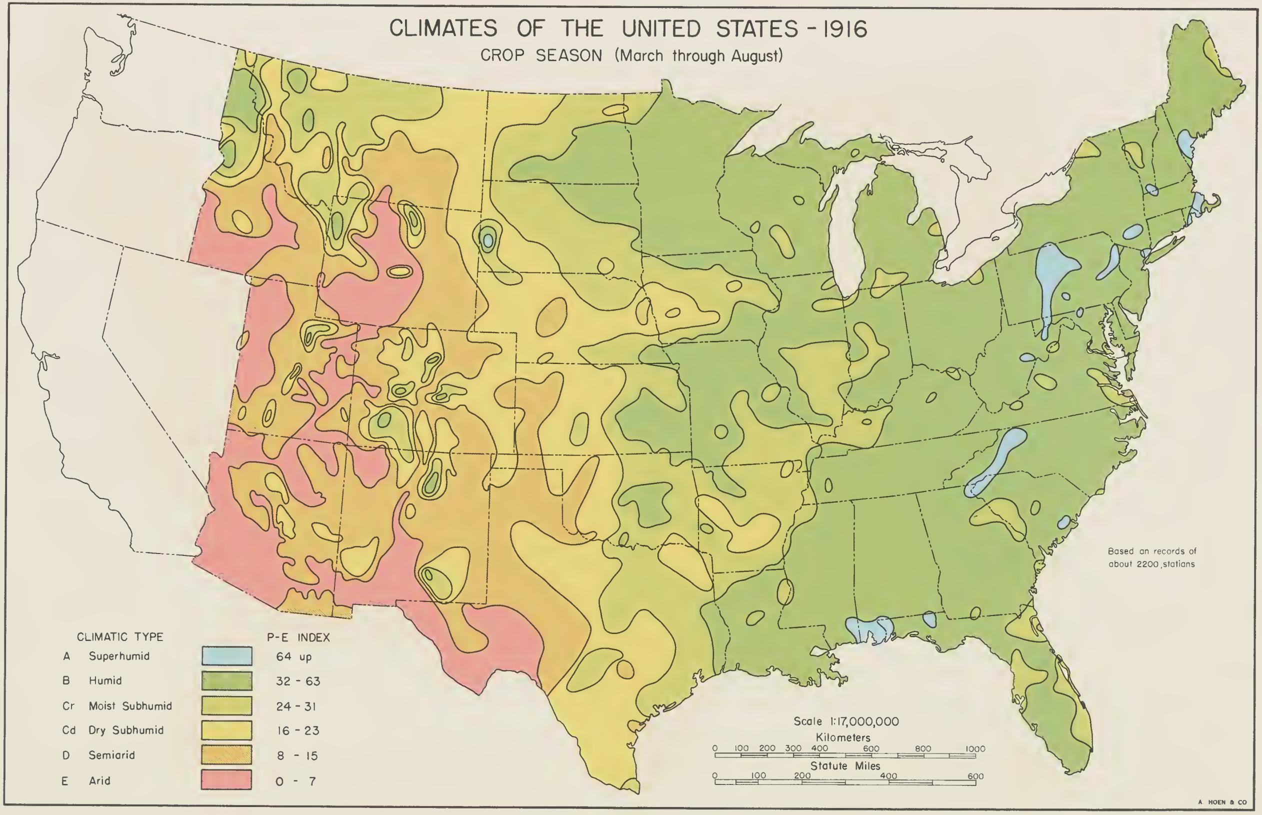
During the crop season of 1915, humid climate extended westward to the Rocky Mountains in Colorado and well into the Texas and Oklahoma Panhandles. Most of South Dakota was humid. Islands of superhumid climate appeared in a number of States west of the Mississippi. Subhumid climates, however, were extensive in the Southeast, the Lake States, and New England.

Plate 37



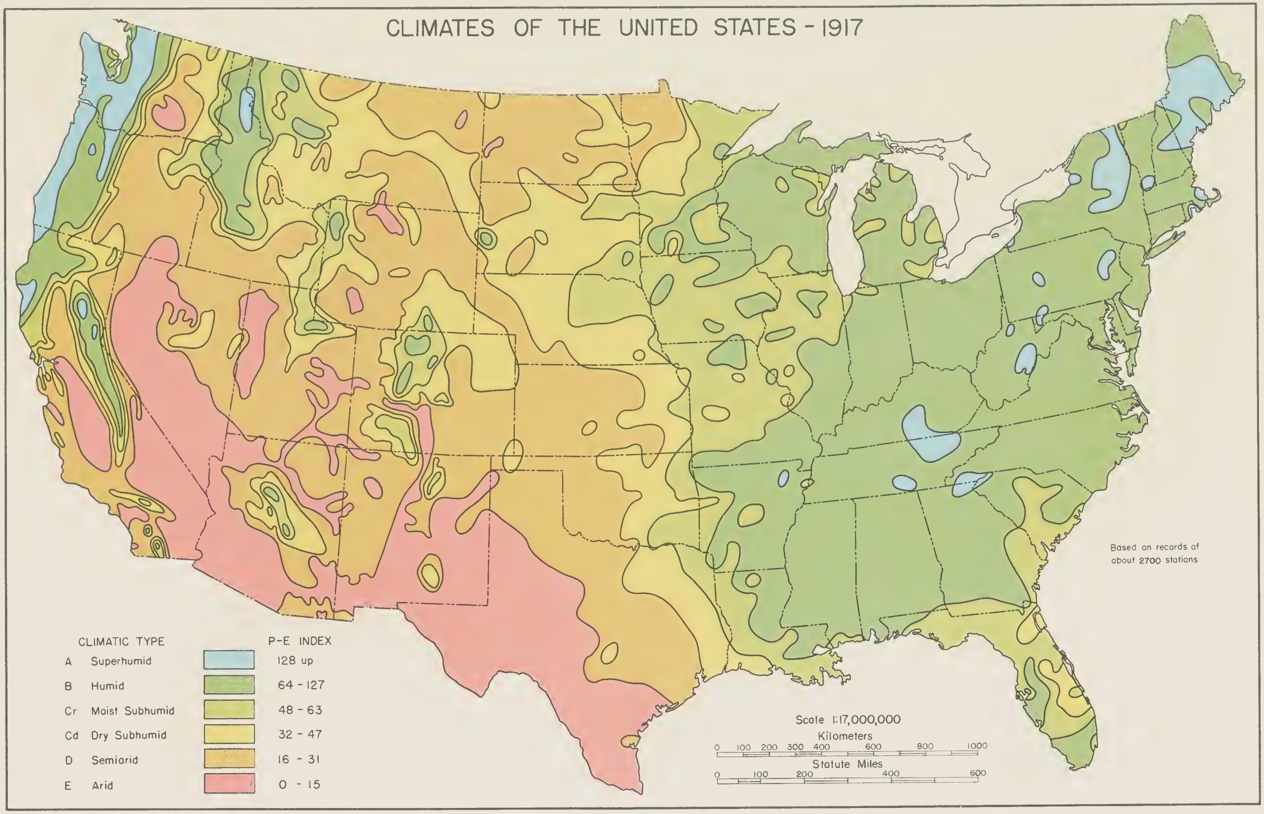
In 1916 except for minor irregularities, the climatic pattern was approximately normal. The semiarid climate of the northern Great Plains was replaced by dry subhumid. The moist-subhumid zone extending from the Gulf to the Canadian border was more irregular and narrow than usual. Superhumid and humid climates were extensive along the Pacific coast, and the areas of arid climate of the San Joaquin Valley in California, and of eastern Washington, had virtually disappeared. Superhumid climate was also extensive in the Northeast. Subhumid climate, however, appeared in South Carolina, Georgia, and Florida

Plate 38



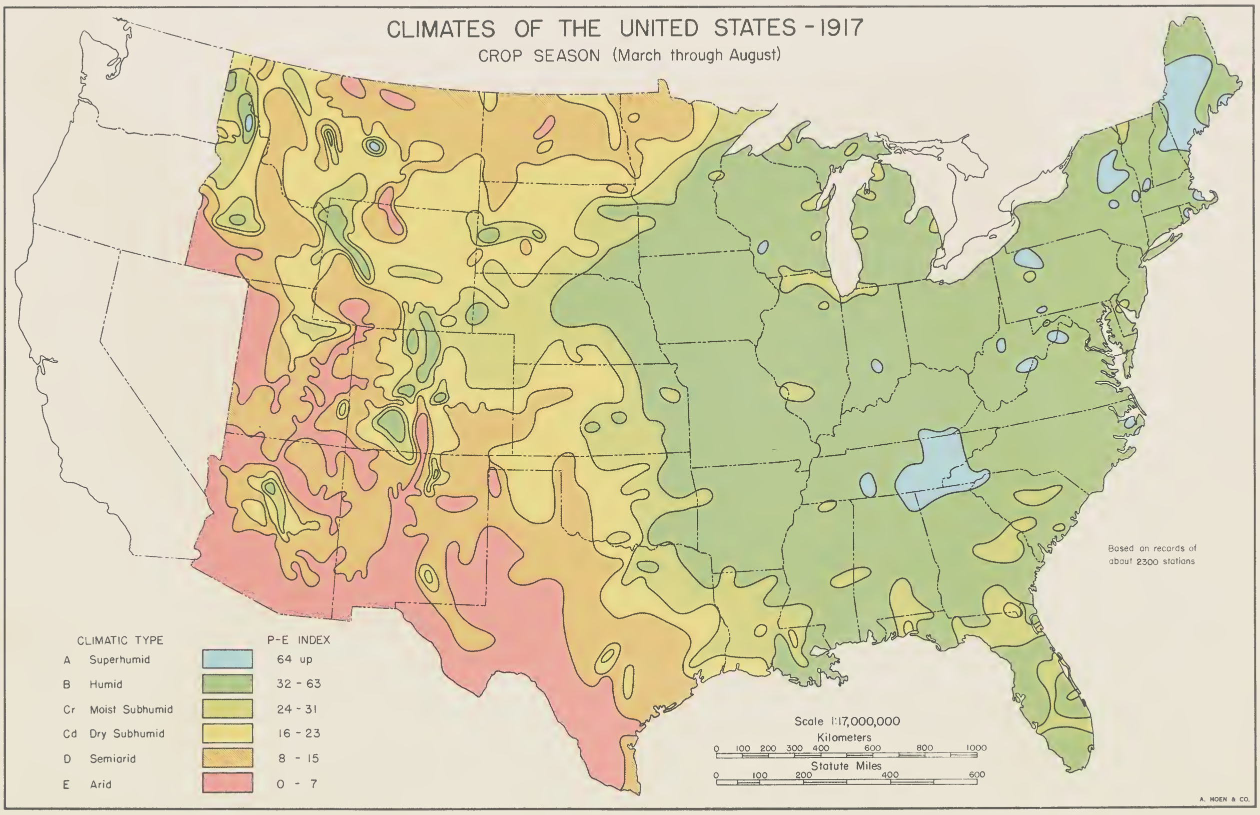
During the crop season of 1916, humid climate pushed westward across Minnesota into North Dakota and South Dakota. Subhumid climates extended eastward in two lobes, one through Iowa and the other through Arkansas and up the Ohio Valley. Arid climate was expanded in western Wyoming and in west Texas. A part of Montana ordinarily semiarid and dry subhumid was moist subhumid.

Plate 39



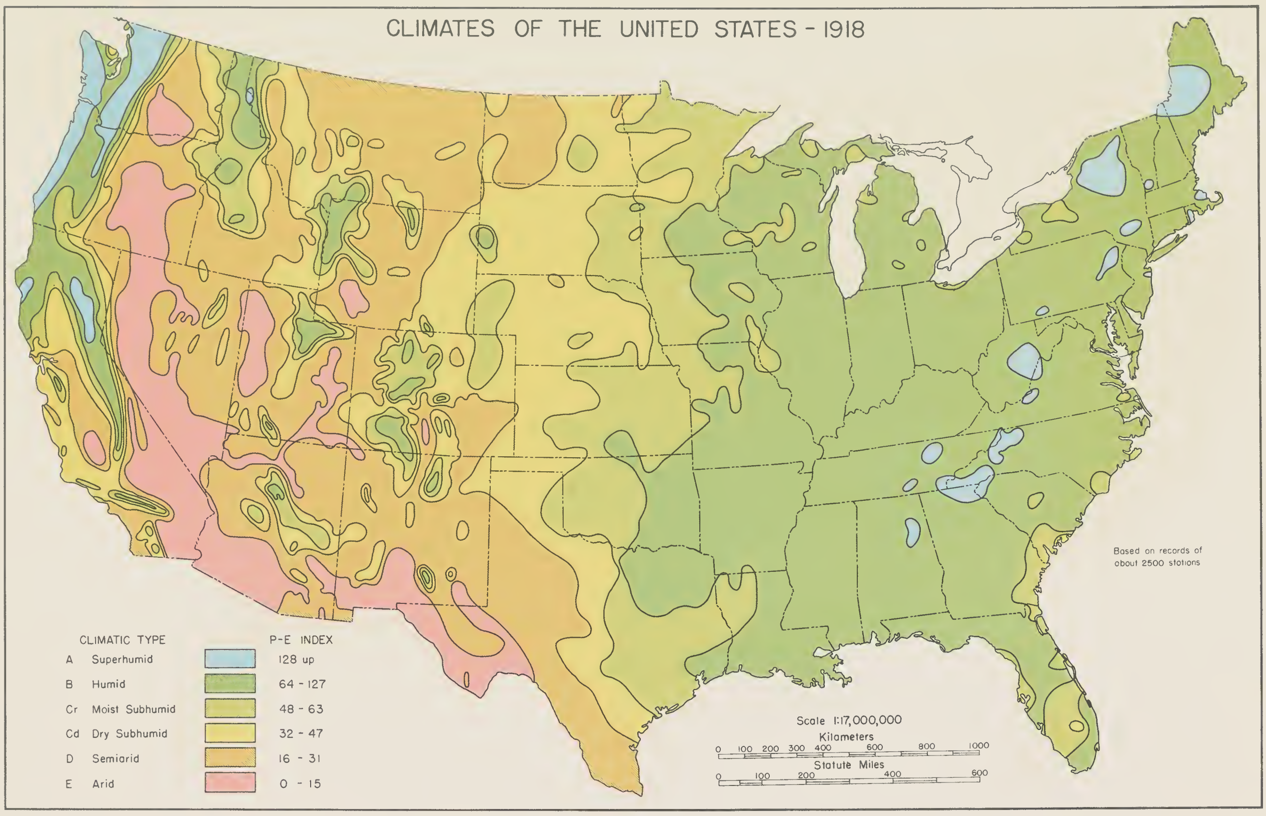
In 1917 the arid and semiarid climates were much more extensive than usual. More than half of Texas and approximately half of New Mexico were arid. The semiarid area moved eastward to central Oklahoma and eastern Kansas. Most of North Dakota and a part of Minnesota was semiarid. Most of the part of California ordinarily subhumid was semiarid. Two small arid areas appeared in western North Dakota and eastern Montana, and three others in the coastal valleys of southern California. The eastern humid region was considerably reduced in size, but within it there were several superhumid islands.

Plate 40



During the crop season of 1917 the northern and southern Great Plains suffered serious drought, but the central Great Plains, including western Nebraska and northeastern Colorado, were much more moist than usual; the humid climate extending westward into central Nebraska, and the moist subhumid extending across Colorado to the Rockies. A fairly large superhumid area appeared in eastern Tennessee and neighboring States. Much of Maine was also superhumid. Arid climate was extensive in southwest Texas and southeastern New Mexico. There were also several small arid islands in Montana, North Dakota, northeastern New Mexico, and the Texas Panhandle.

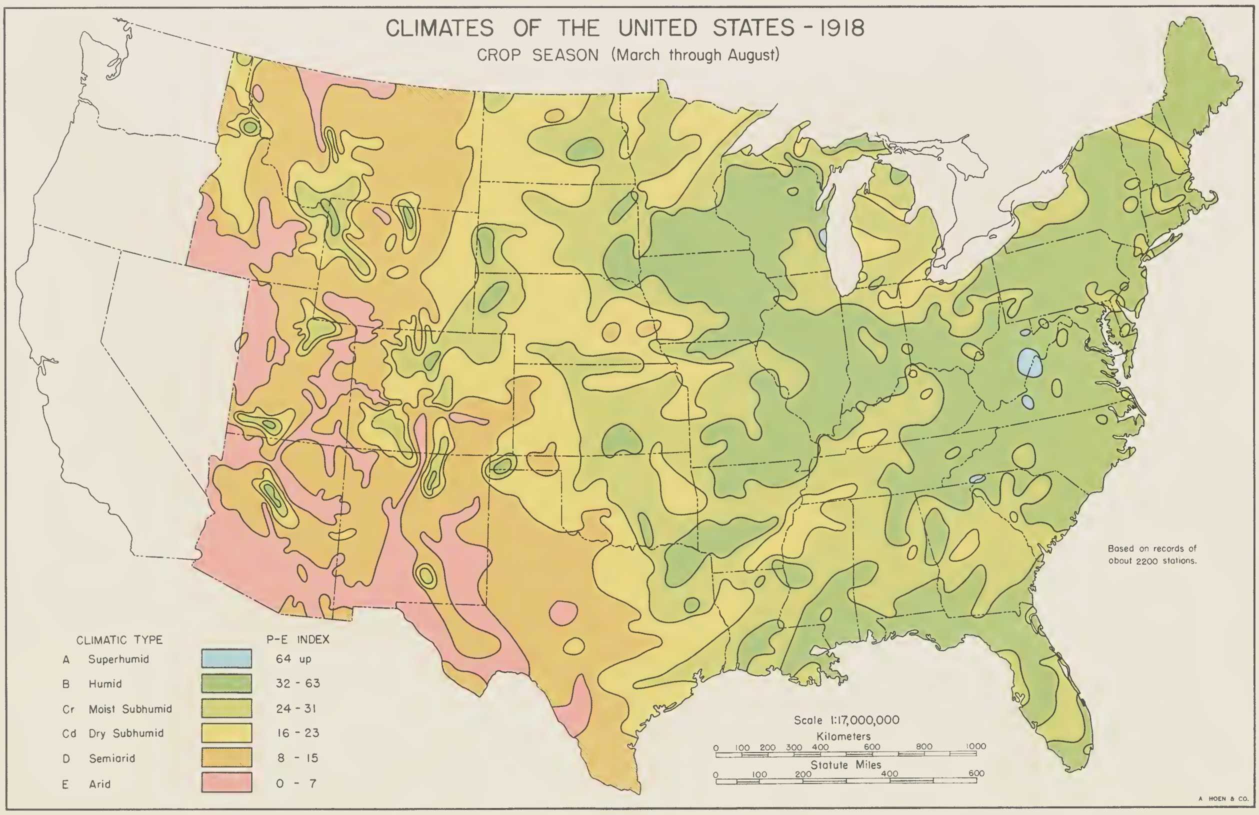
Plate 41


CLIMATES OF THE UNITED STATES - 1918

Based on records of about 2500 stations

In 1918 there were two regions in which humid climate extended somewhat west of its normal position. These were Oklahoma and northeast Texas, and eastern Iowa and southeastern Minnesota. In northern Minnesota, northwestern Missouri, southeastern Texas, and western Louisiana, humid climate was displaced eastward by moist subhumid. Otherwise, except for minor irregularities, moist subhumid climate occupied approximately its normal position. The dry subhumid, however, extended entirely across the Great Plains in Colorado and far west in Nebraska, South Dakota, and Wyoming. Kansas and the Oklahoma and Texas Panhandles were also dry subhumid. The arid climate was more extensive than usual in Nevada and pushed up into eastern Oregon and was considerably expanded in eastern Washington.

Plate 42

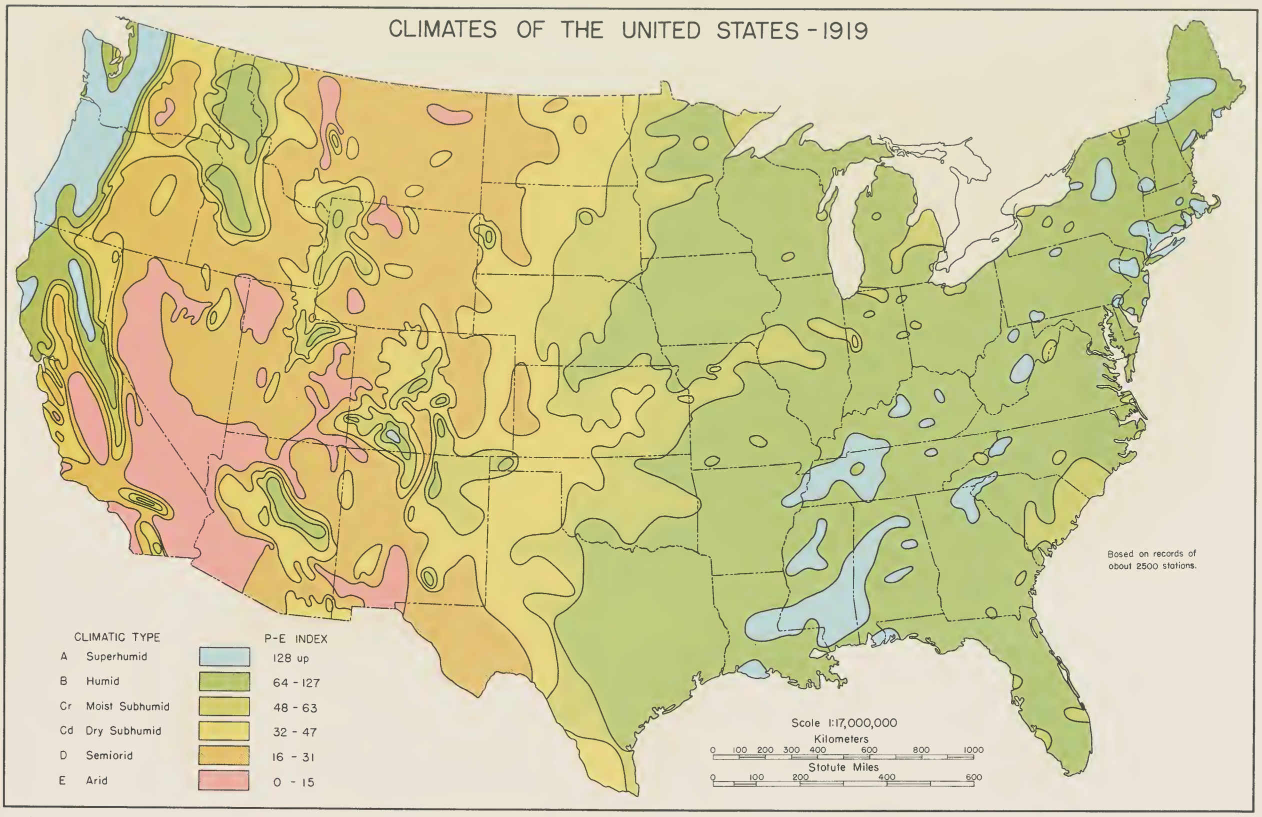

CLIMATES OF THE UNITED STATES - 1918
CROP SEASON (March through August)

Based on records of about 2200 stations.

During the crop season of 1918, the distribution of climate was extremely spotty, with large subhumid areas appearing in the East. Arid climate appeared in northern Montana, southeastern Colorado, eastern New Mexico, and in two small areas in west Texas.

Plate 43

CLIMATES OF THE UNITED STATES - 1919

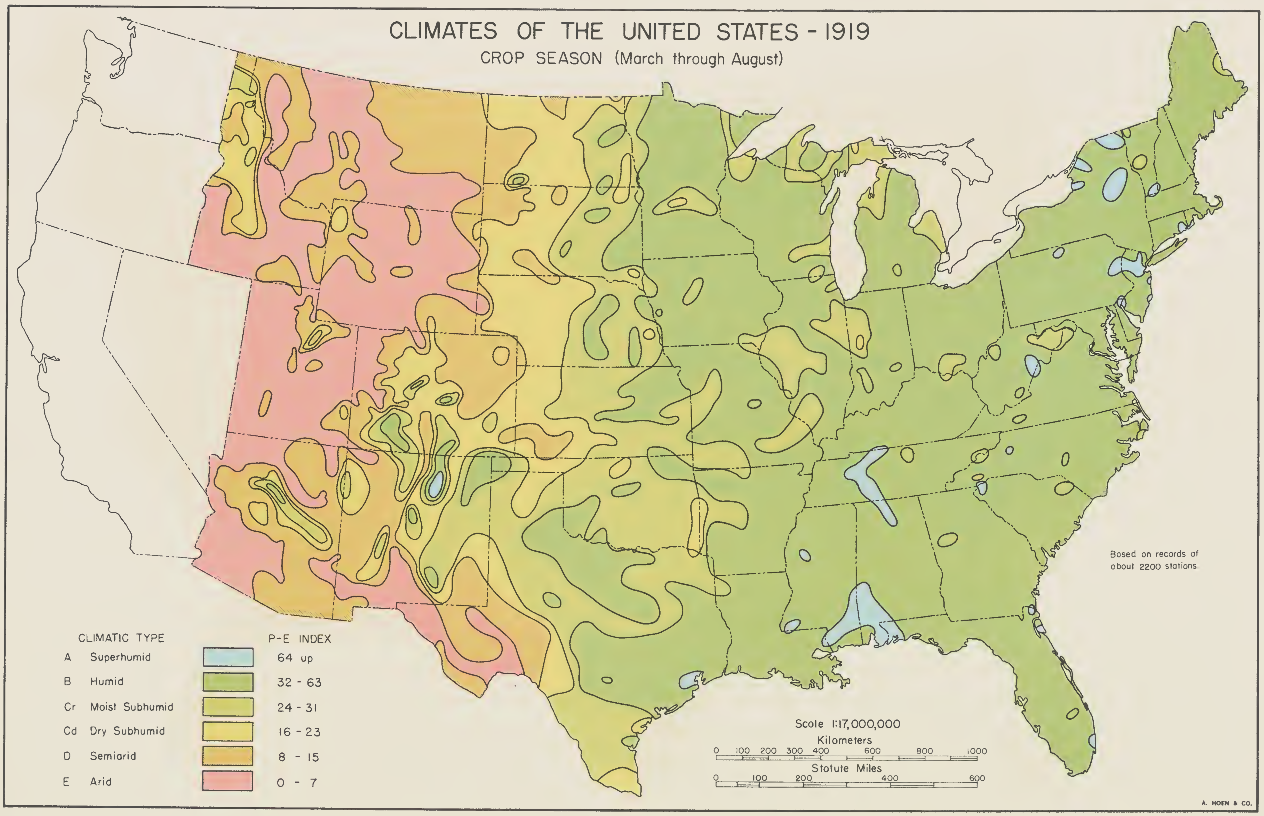


In 1919 islands of superhumid climate again appeared along an axis extending from the mouth of the Mississippi to New England. Texas, as far west as the normal position of the semiarid boundary, was humid. The humid area also extended westward across Iowa into eastern Nebraska and northeastern Kansas, and the moist-subhumid belt was displaced westward in Texas, Nebraska, and Kansas. In the southern Plains semiarid climate was missing altogether, and in the northeastern part of New Mexico and the Oklahoma Panhandle an area of moist subhumid appeared. Semiarid climate occupied its normal range in the northern Plains, but in Montana two arid areas appeared. The coastal area of North Carolina and South Carolina was moist subhumid. Superhumid climate was considerably expanded in Washington and Oregon.

Plate 44

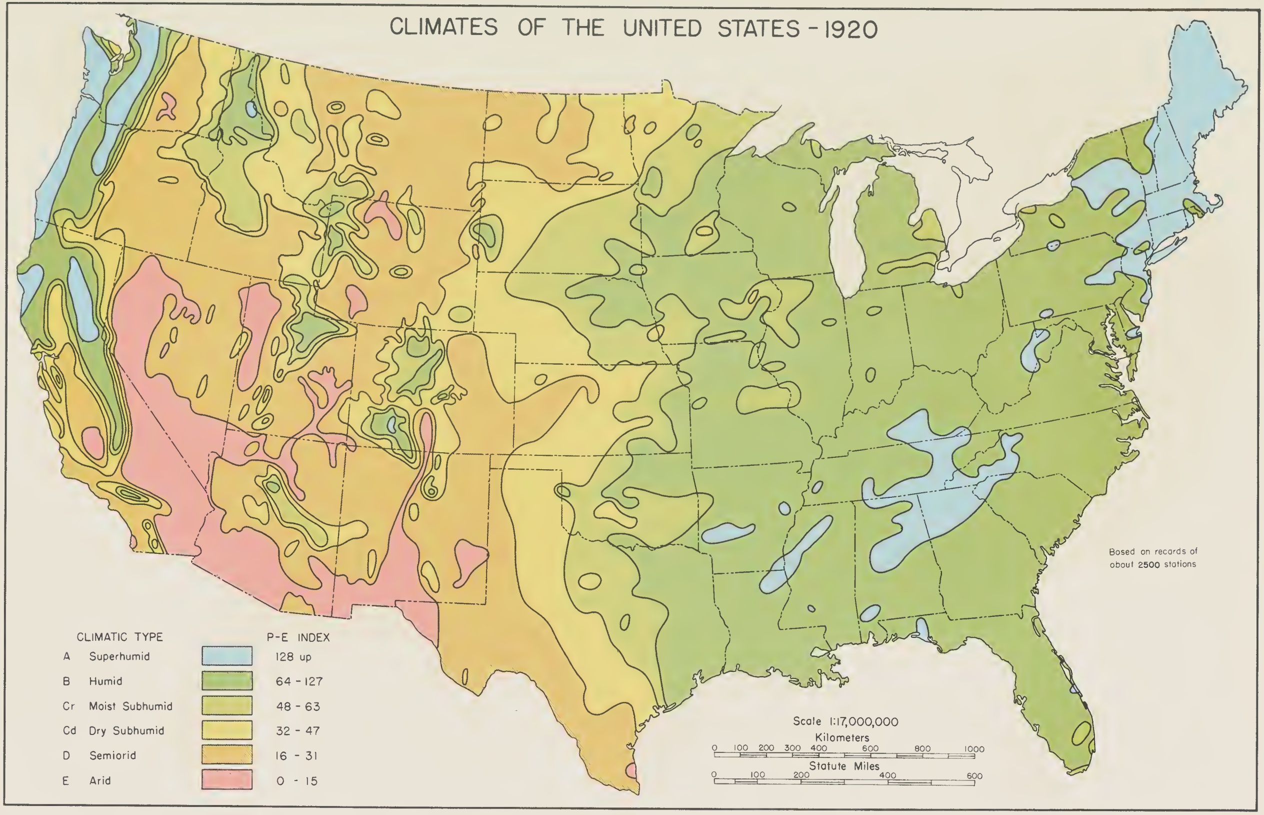
CLIMATES OF THE UNITED STATES - 1919

CROP SEASON (March through August)



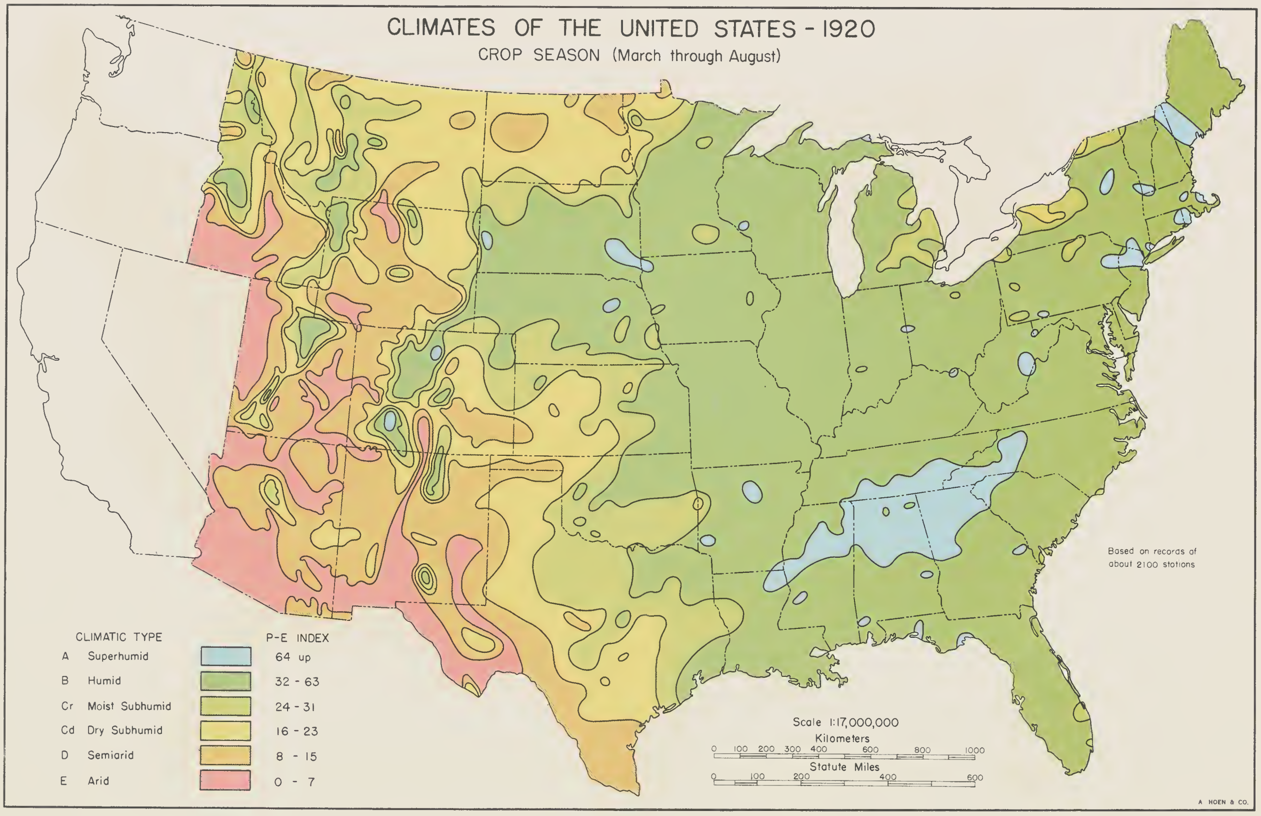
Conspicuous during the crop season of 1919 were the westward extension of humid and moist subhumid climates in Texas, Oklahoma, and New Mexico and the great expansion of arid climate in the northern Plains and Rocky Mountain States. Most of Utah and Wyoming and much of Idaho and Montana were arid. Small areas of both superhumid and subhumid climates appeared throughout the East.

Plate 45



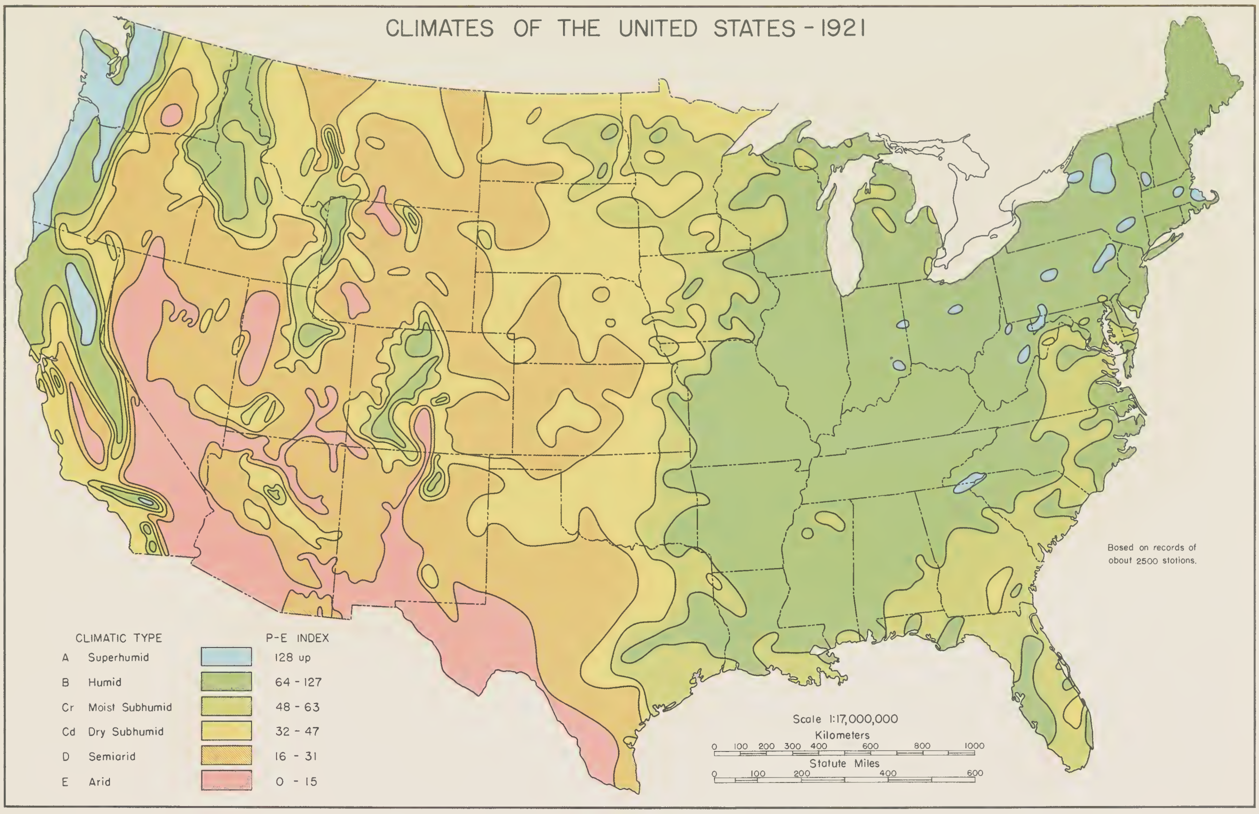
In 1920 several large areas of superhumid climate appeared in the East. One occupied most of New England, New York, and New Jersey, and another centered around the southern Appalachians. Smaller areas appeared in the lower Mississippi Valley. The humid-subhumid boundary was much more irregular than usual, with a number of humid lobes extending westward, separated by subhumid reentrants. Several subhumid islands appeared in the Corn Belt and the Lake States. The moist-subhumid belt was unusually narrow throughout most of its extent. South Dakota and Nebraska were considerably moister than usual. In the South, areas of arid climates appeared in southeastern New Mexico and on the Gulf coast of Texas. The arid area in west Texas, however, was smaller than usual.

Plate 46



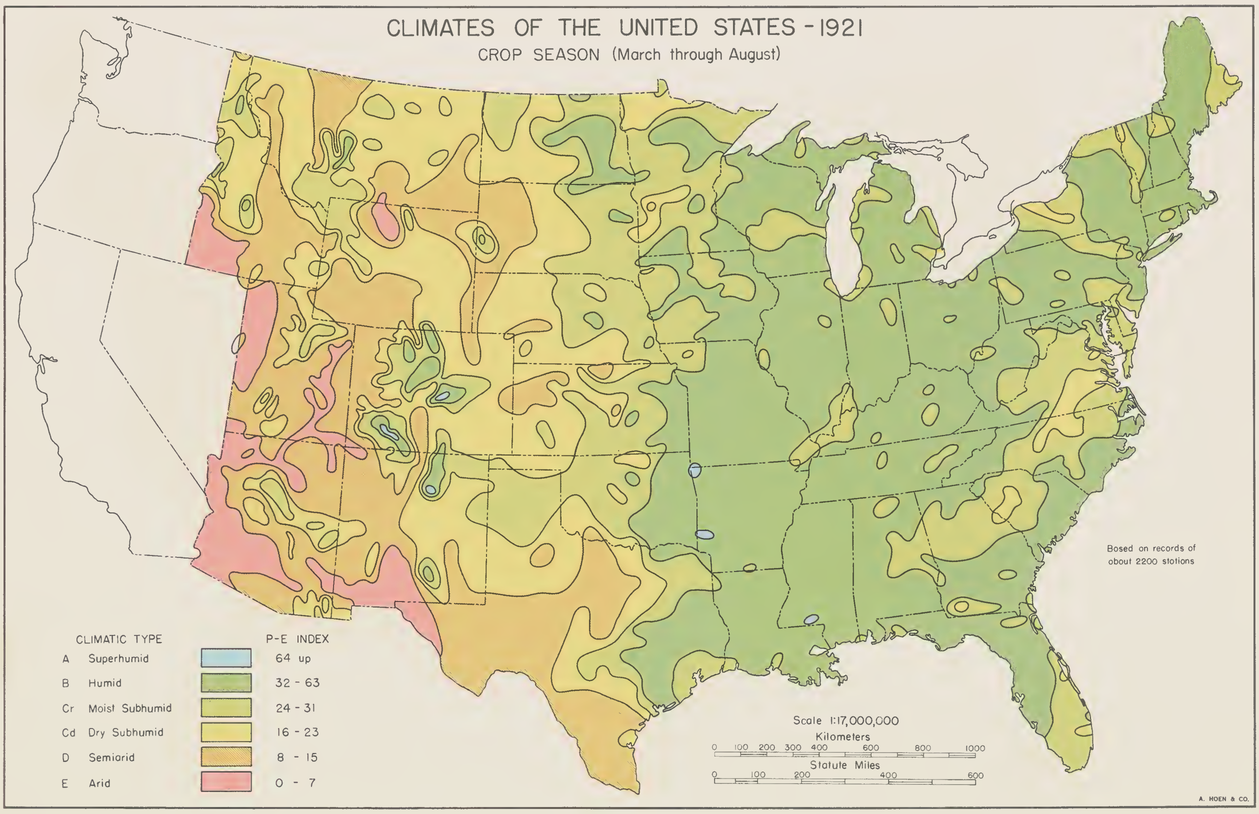
During the crop season of 1920, humid climate occupied most of South Dakota and Nebraska, and most of Montana and North Dakota were either moist subhumid or dry subhumid. Small semiarid islands, however, appeared in eastern North Dakota and northern Minnesota. A large superhumid area extended from Louisiana northeastward well into North Carolina. Small areas of superhumid climate appeared in South Dakota and Nebraska.

Plate 47



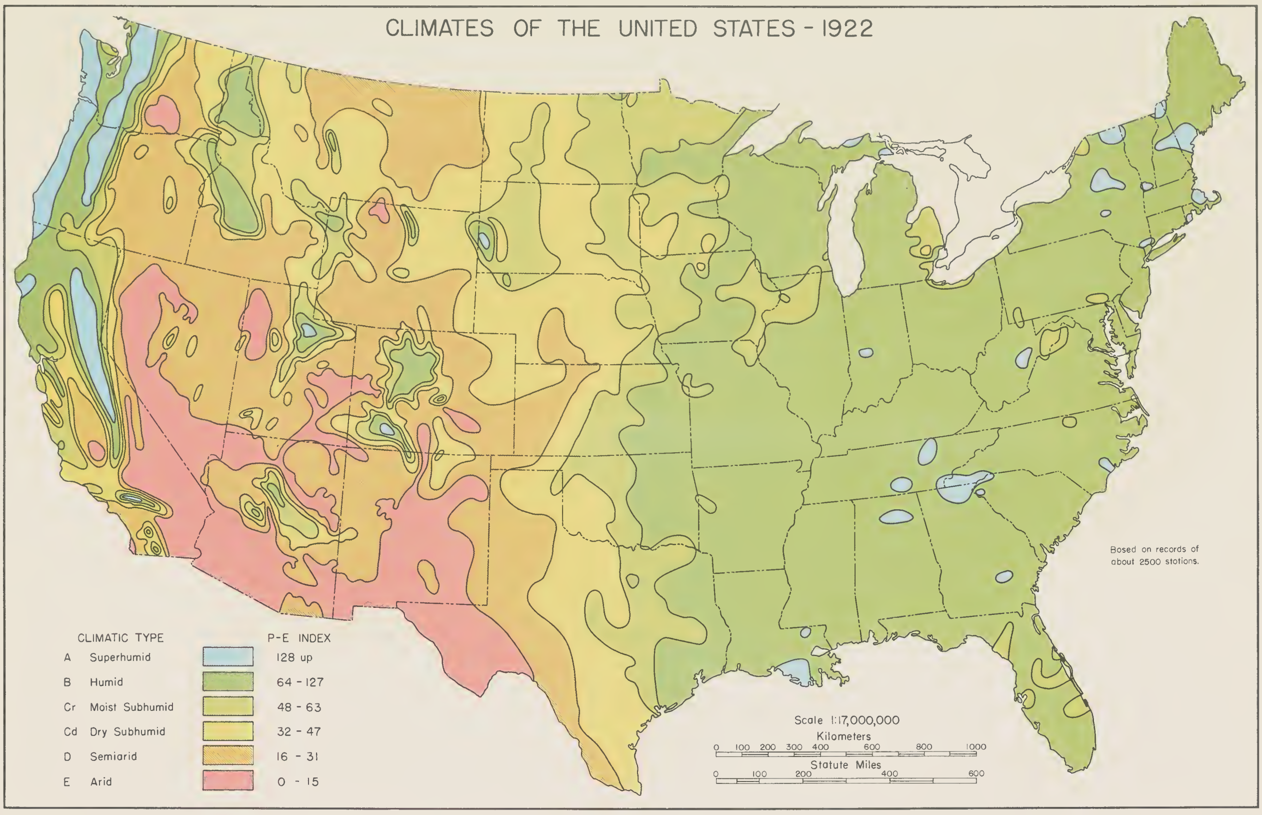
In 1921 the semiarid and both subhumid belts through the central part of the United States were very irregular. The moist-subhumid belt was much narrower than usual. Three lobes of dry-subhumid climate pushed westward into the Plains, and between them three semiarid lobes extended eastward into the prairies. Arid climate was considerably expanded in southwest Texas. Washington was considerably moister than usual, the superhumid area being expanded and the customarily arid area being diminished in size.

Plate 48



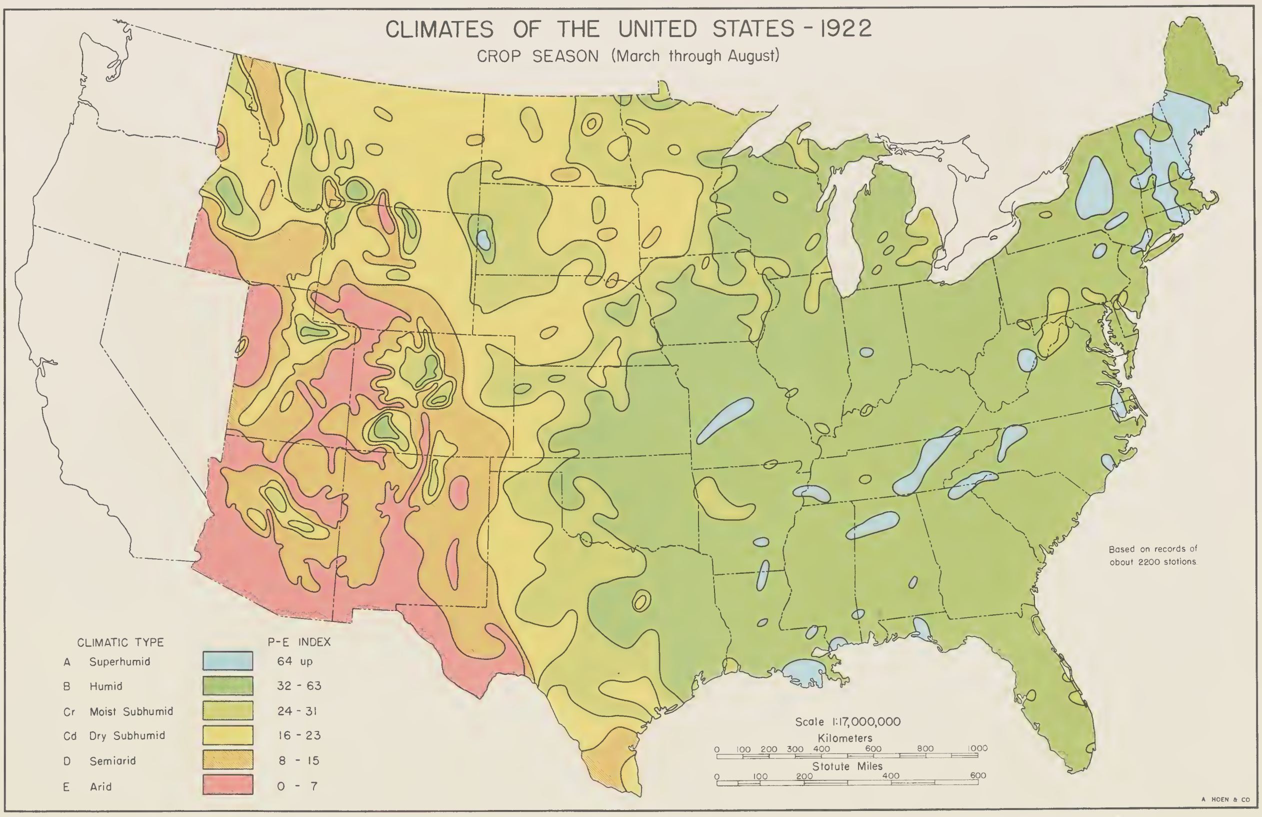
During the crop season of 1921 the semiarid and subhumid belts running north and south through the central part of the country were very irregular. A large area extending from Alabama to New Jersey was subhumid. Smaller islands of moist-subhumid and dry-subhumid climates were present throughout the Eastern States. Minnesota and Iowa were drier than usual. Arid climate was much restricted and was entirely missing from Texas.

Plate 49



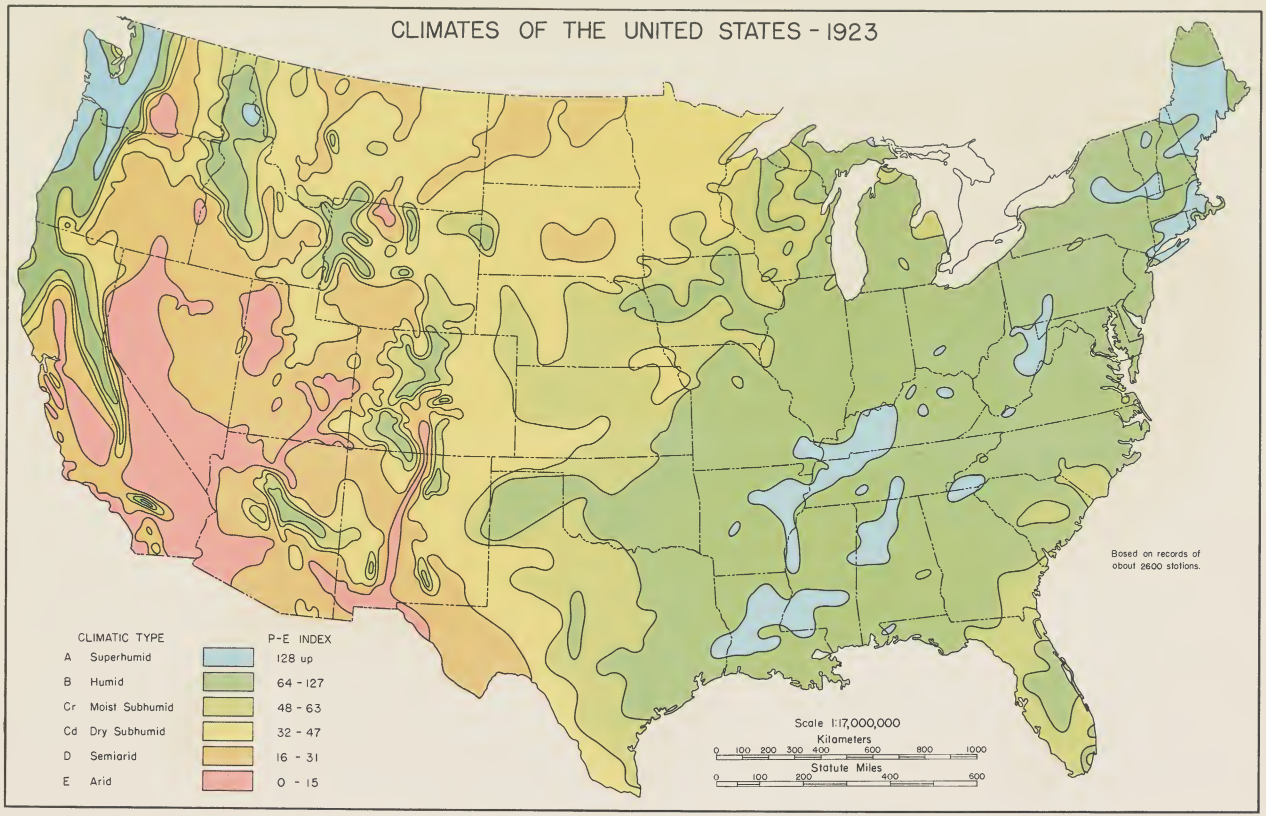
In 1922 except for minor irregularities, the climatic distribution was normal. A few superhumid islands appeared along an axis extending from the mouth of the Mississippi to New England. Humid climate expanded slightly westward in Oklahoma, Kansas, and Iowa. Moist-subhumid climate also was extended in these States and in the Dakotas. In the northern Great Plains dry-subhumid climate was displaced westward and was more extensive than usual.

Plate 50



During the crop season of 1922 humid climate extended far into Texas, Oklahoma, and Kansas, and moist subhumid occupied the Texas Panhandle, eastern Colorado, and much of western South Dakota. However, a lobe of dry-subhumid climate containing several semiarid islands extended eastward from Nebraska and South Dakota into Minnesota. Two small arid areas appeared in eastern New Mexico. Spots of superhumid climate were widely distributed throughout the eastern humid region. Montana was more moist than usual.

Plate 51

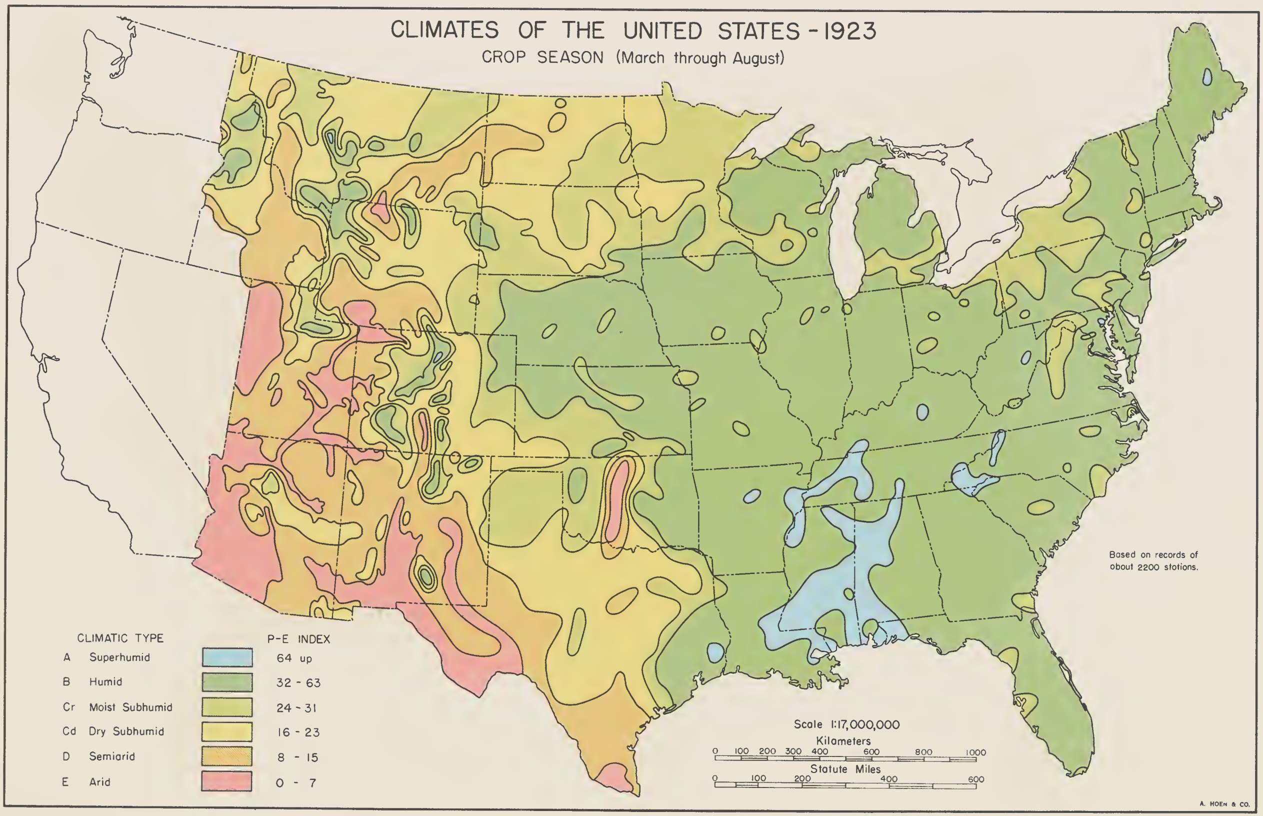


CLIMATES OF THE UNITED STATES - 1923

Based on records of about 2600 stations.

In 1923 superhumid climates again appeared along an axis extending from Louisiana to New England with the major concentration in the lower Mississippi Valley. A humid extension crossed Oklahoma and occupied most of the Texas Panhandle. Moist-subhumid climate occupied most of Kansas and Nebraska. Semiarid climate was absent from the region east of the Rockies except in spots in Montana, North Dakota, and South Dakota. Minnesota was largely dry subhumid and Wisconsin moist subhumid. Parts of North Carolina, South Carolina, Georgia, and Florida were moist subhumid. California was far drier than usual, with arid and semiarid climates much extended.

Plate 52



CLIMATES OF THE UNITED STATES - 1923

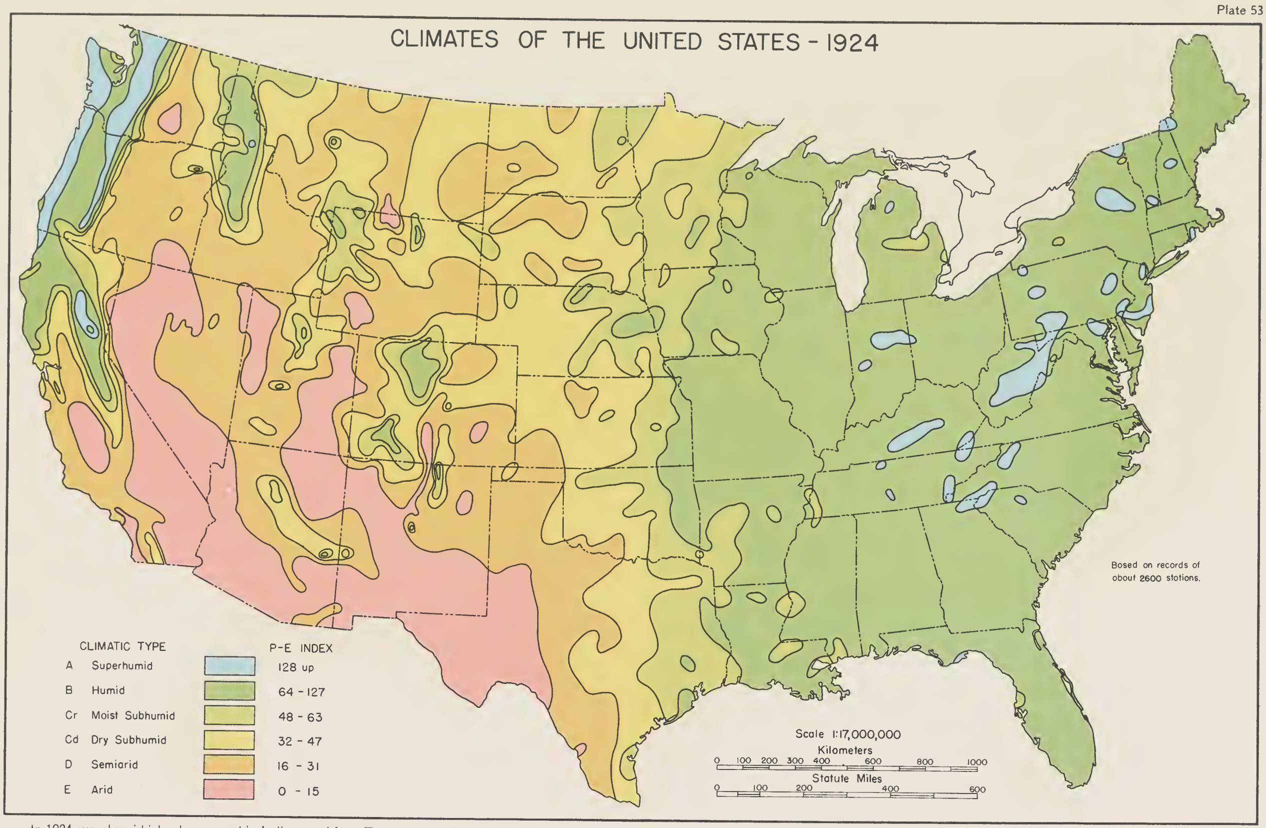
CROP SEASON (March through August)

Based on records of about 2200 stations.

During the crop season of 1923 humid climate occupied most of Nebraska and the northern half of Kansas. Large areas of the central and southern Great Plains were moist subhumid. The central part of Oklahoma experienced its most serious drought on record, a narrow belt of arid climate extending north and south almost entirely across the State. Within a few miles to the west, as well as to the east, was humid climate. Superhumid climate was extensive in the lower Mississippi Valley but was little represented in the North Atlantic States where islands of moist-subhumid climate were numerous.

Plate 53

CLIMATES OF THE UNITED STATES - 1924

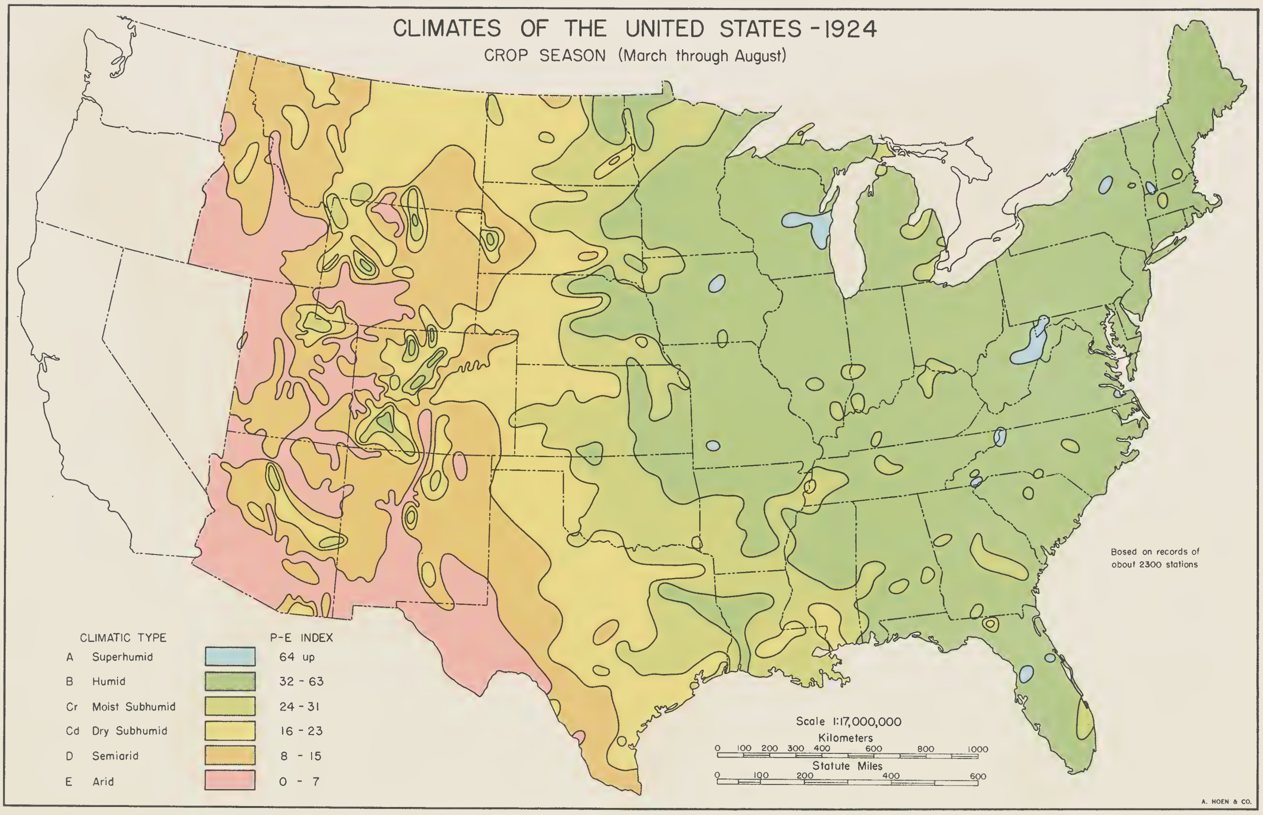


In 1924 superhumid islands occurred in Indiana and from Tennessee northeastward to New England. The humid climate was contracted eastward into Arkansas and into northern Wisconsin, and expanded westward into central Iowa. The moist-subhumid belt was narrow throughout most of its extent. The dry-subhumid belt was narrow and displaced eastward in Texas, but from Oklahoma northward it was much wider than usual and in two places extended westward entirely across the Great Plains. A number of semiarid islands were present in the dry-subhumid belt, however. Arid climate was considerably expanded in the Southwest, the greatest expansion appearing in west Texas, New Mexico, eastern Arizona, and eastern Utah. Arid islands appeared in southeastern Colorado and northeastern New Mexico.

Plate 54

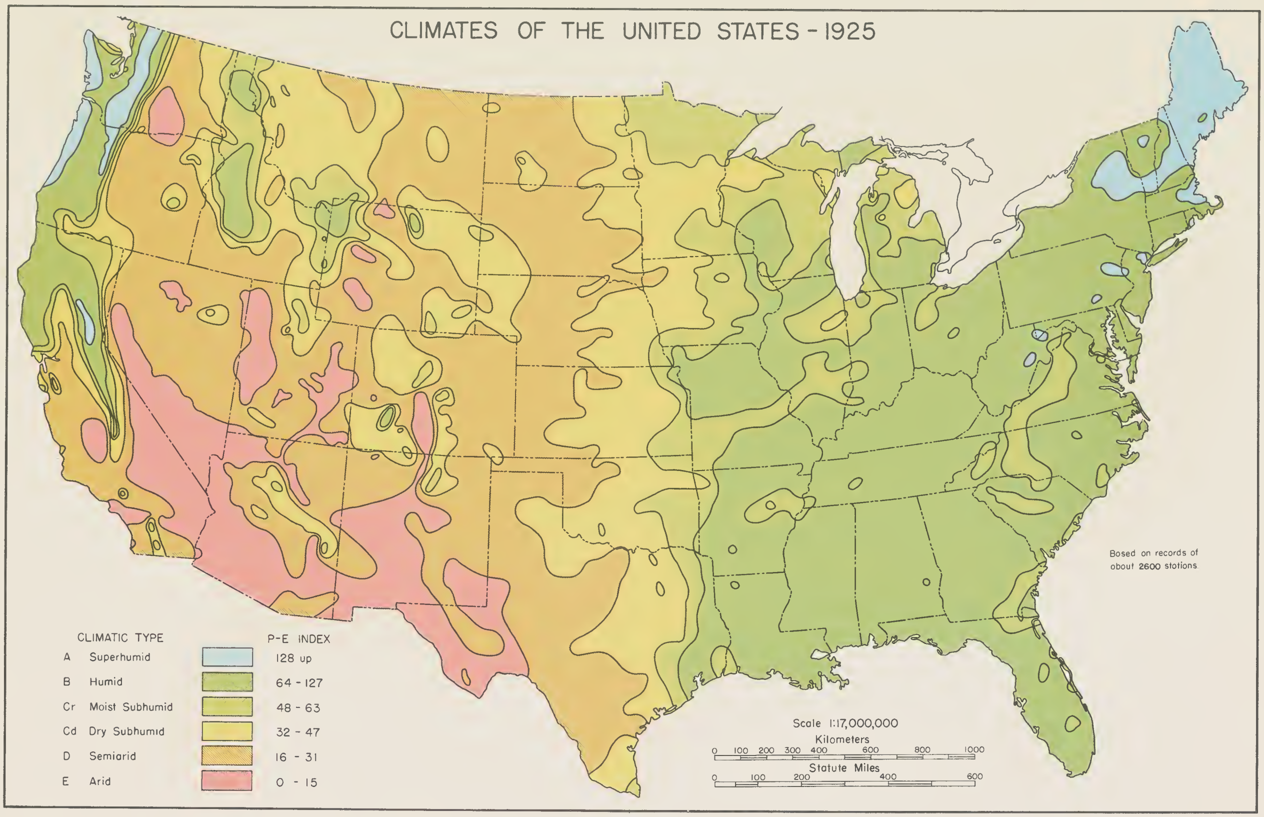
CLIMATES OF THE UNITED STATES - 1924

CROP SEASON (March through August)



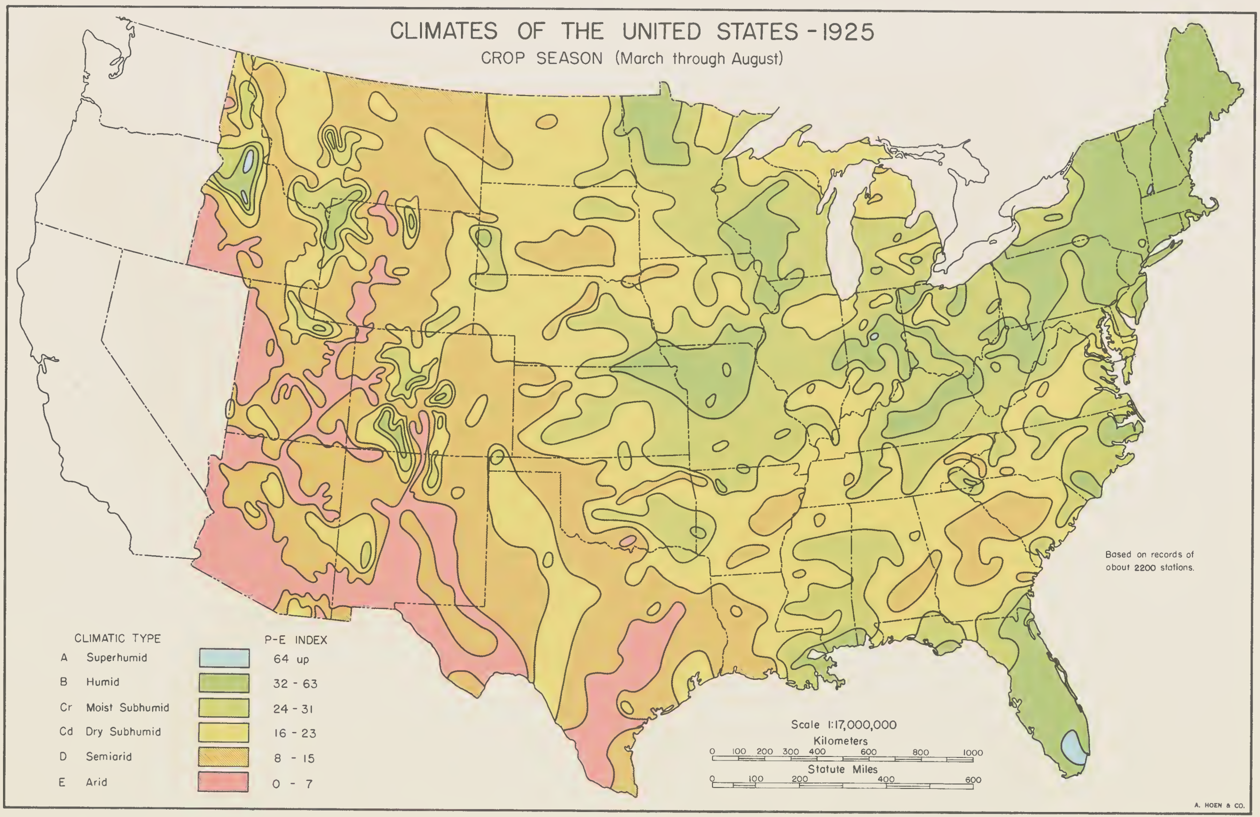
During the crop season of 1924 the area of humid climate was retracted and subhumid climate appeared extensively in Arkansas, Louisiana, and Mississippi. The moist-subhumid was very irregular and narrow across Nebraska and South Dakota. Arid climate was expanded somewhat in Idaho and Wyoming.

Plate 55



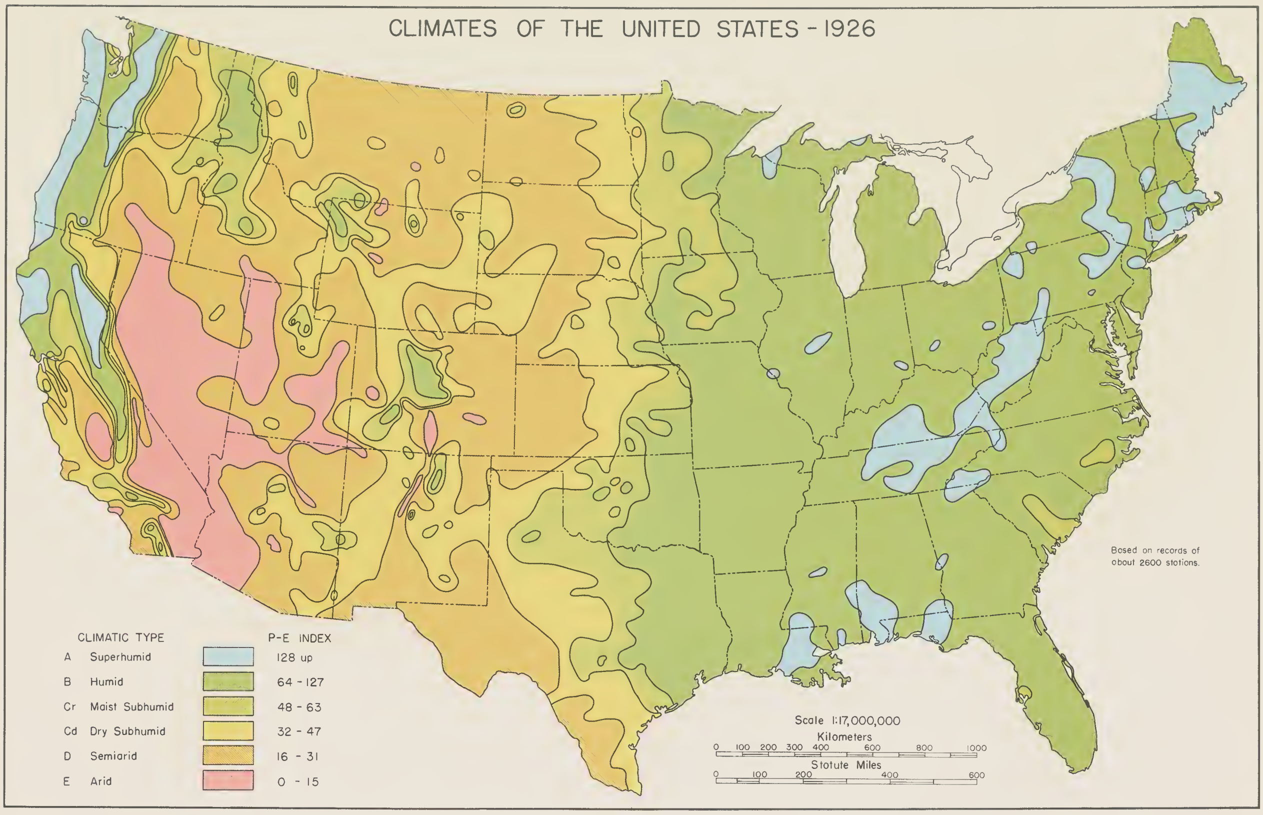
In 1925 arid climate was only slightly more extensive than usual, but the semiarid climate was expanded considerably eastward from the Great Plains and displaced the subhumid and humid climates eastward. The moist-subhumid belt was very narrow throughout, and extremely irregular from Missouri northward. Much of Wisconsin and Michigan was subhumid. The Piedmont of the Carolinas and Virginia was in large part moist-subhumid. Superhumid climate was extensive in northern New England.

Plate 56



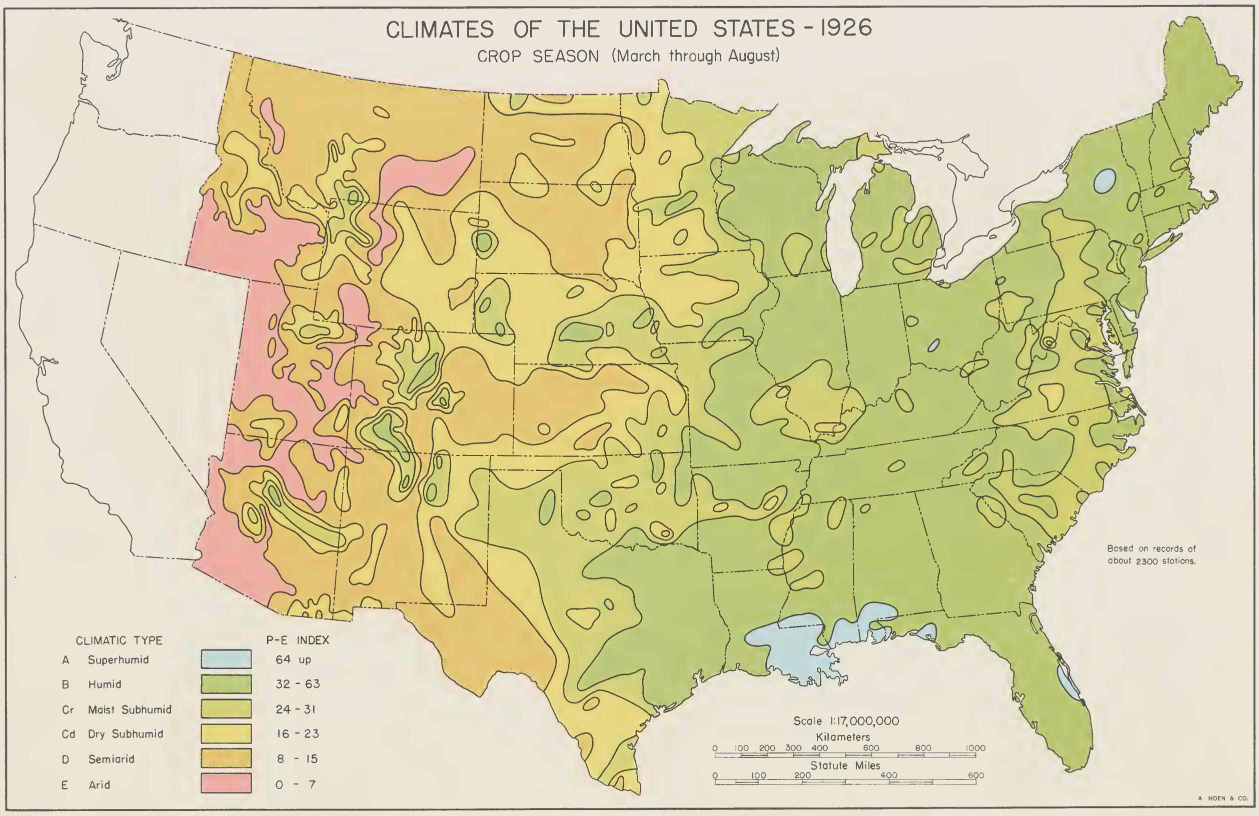
During the crop season of 1925 nearly the whole country was drier than usual and the distribution of climate was universally spotty. Humid climate appeared only in scattered areas in the North and Northeast, in the Central States, and in Florida and along the Gulf coast. In the South even moist-subhumid climate was relatively inextensive and both dry-subhumid and semiarid were extensive. A large semiarid area occupied much of South Carolina and Georgia, and semiarid climate also pushed eastward across Texas into Louisiana. Much of east Texas was arid and a small arid area also appeared in south-central Oklahoma. Northwestern Minnesota, ordinarily moist subhumid, was humid.

Plate 57



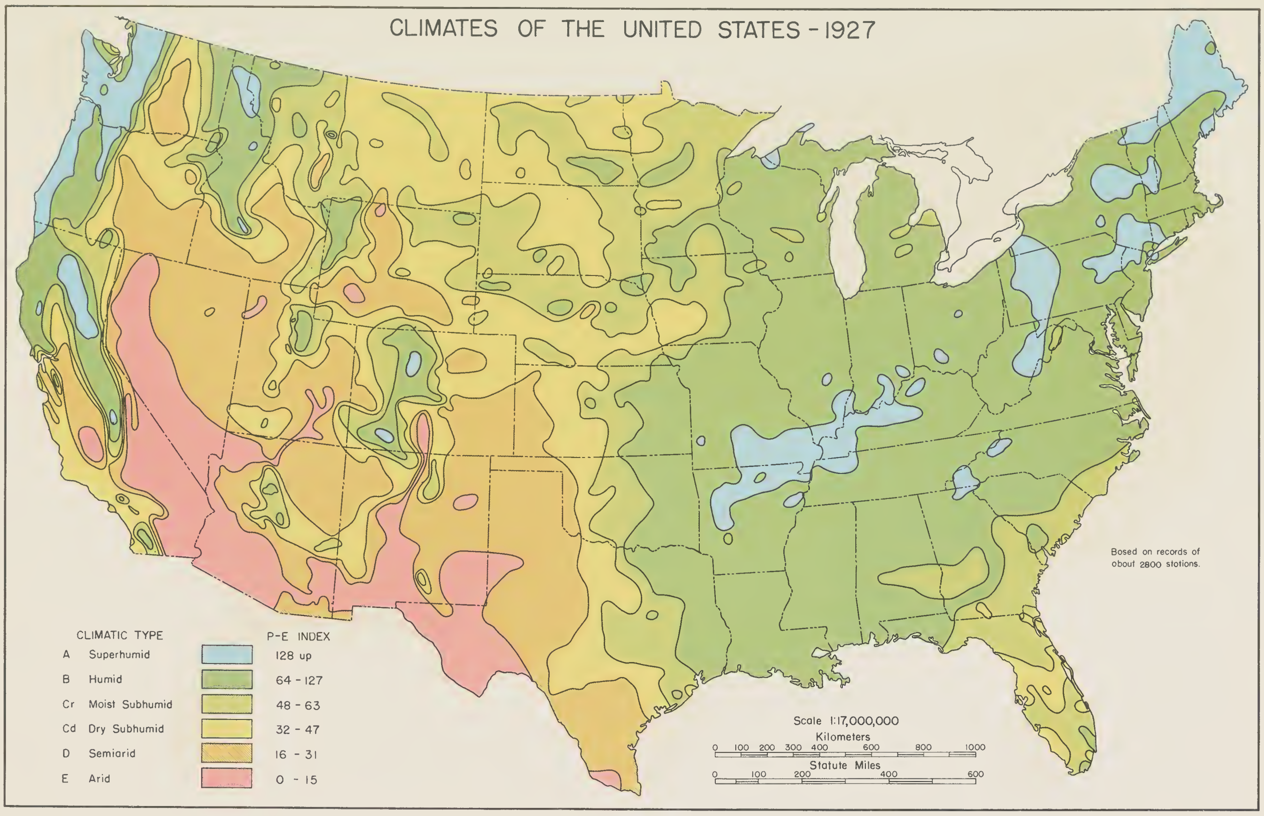
In 1926 humid climate occupied approximately its normal position in eastern United States. Along the axis from Louisiana to New England superhumid climate was considerably more extensive than usual. Both moist-subhumid and dry-subhumid climatic belts in the middle of the country were abnormally narrow and the semiarid climate again extended eastward into the subhumid area, particularly in the central and northern part of its range. Humid, moist-subhumid, and dry-subhumid climates extended far westward in southern Oklahoma, the Texas Panhandle, and New Mexico. The arid climates were considerably reduced in area and were completely lacking in Texas and nearly so in New Mexico and eastern Arizona. Two small arid areas appeared, in southeastern Colorado and east-central Montana.

Plate 58



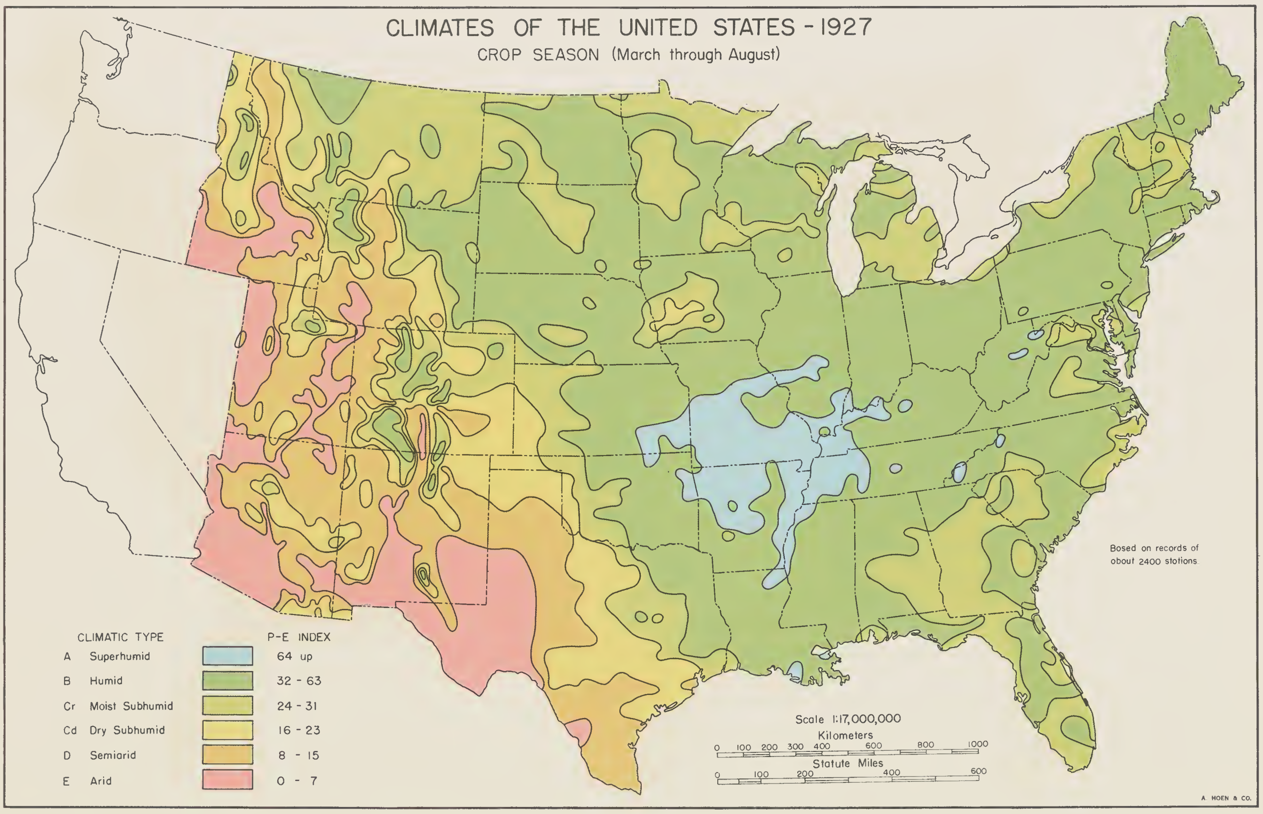
During the crop season of 1926 humid climate advanced westward in Texas but retreated eastward in Iowa and Minnesota. A large superhumid area appeared in the Mississippi Delta and along the Gulf coast. Both subhumid belts were extremely irregular. A narrow belt of moist subhumid extended from central New York southward to the Atlantic coast in South Carolina. A small spot of semiarid climate appeared in West Virginia. Another moist-subhumid area centered in southern Illinois. Moist subhumid extended westward across Oklahoma and the Texas Panhandle and into eastern New Mexico. Dry-subhumid and semiarid lobes pushed eastward across Kansas and across the Dakotas. A large area of arid climate appeared in eastern Montana, as an extension of the desert of north-central Wyoming. Arid climates, however, were entirely absent from Texas and most of New Mexico.

Plate 59



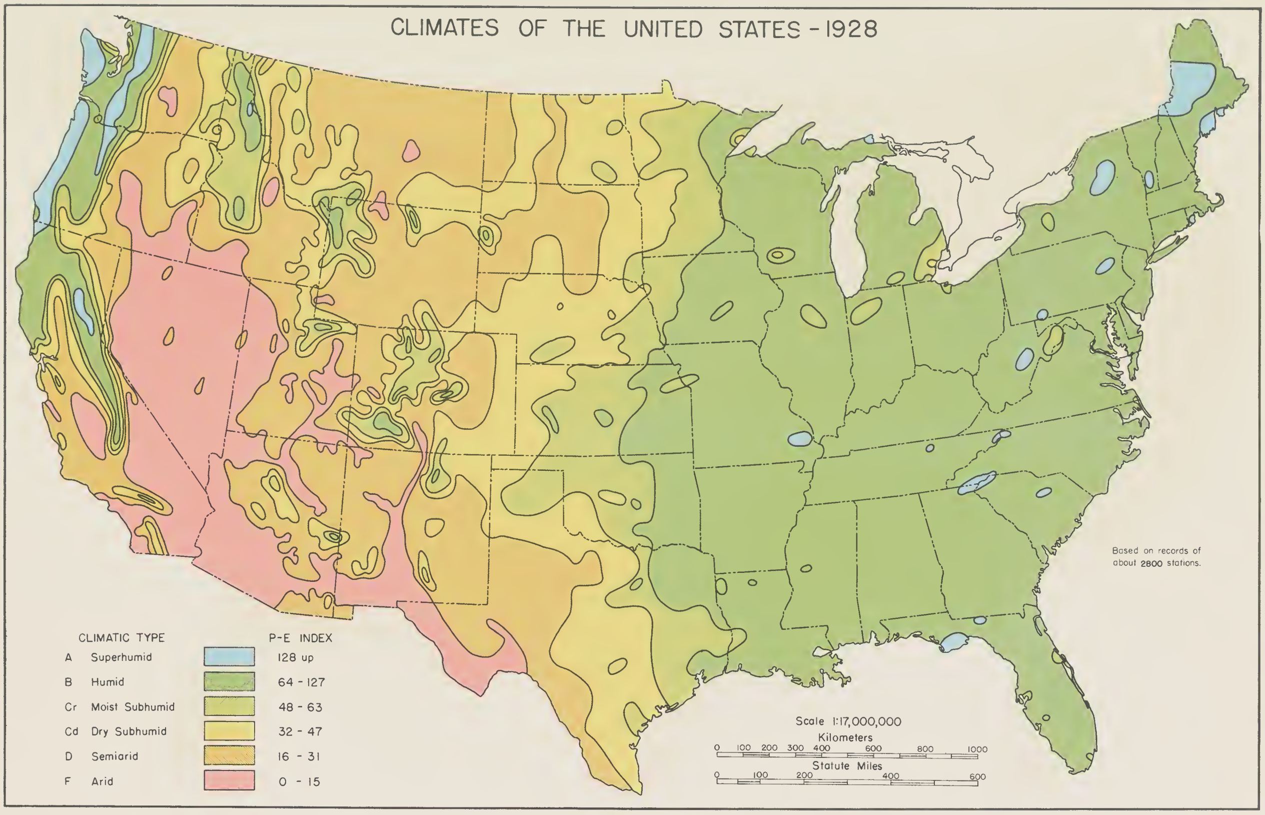
In 1927 large areas in the central Mississippi Basin and along an axis from Arkansas to New England were superhumid. The western boundary of the humid climate was slightly west of its normal position in the South and somewhat east in the extreme North. Coastal areas of the Southeastern States were moist subhumid. Dry-subhumid areas appeared in Florida. Semiarid climate was expanded eastward somewhat from its normal position in Texas and Oklahoma, but north of Kansas and Colorado was almost entirely absent from the Great Plains. Climate in the North was principally dry subhumid, but two great lobes of moist subhumid extended far west across the Dakotas and Nebraska into Wyoming and Montana. The Pacific Northwest was more moist than usual, and the arid area normal to eastern Washington was absent. In west Texas and southeastern New Mexico arid climates were somewhat more extensive than usual. Small arid islands appeared in northeastern New Mexico and in the lower Rio Grande Valley in south Texas.

Plate 60



During the crop season of 1927 a huge area embracing parts of several States centering on the Mississippi at the mouth of the Ohio was superhumid. Nearly all the northern part of the country east of the Rockies was humid and moist subhumid. In south Texas and New Mexico the arid area was somewhat expanded. A small area in Iowa was moist subhumid and dry subhumid. Other areas of moist-subhumid climate appeared in the South Atlantic States.

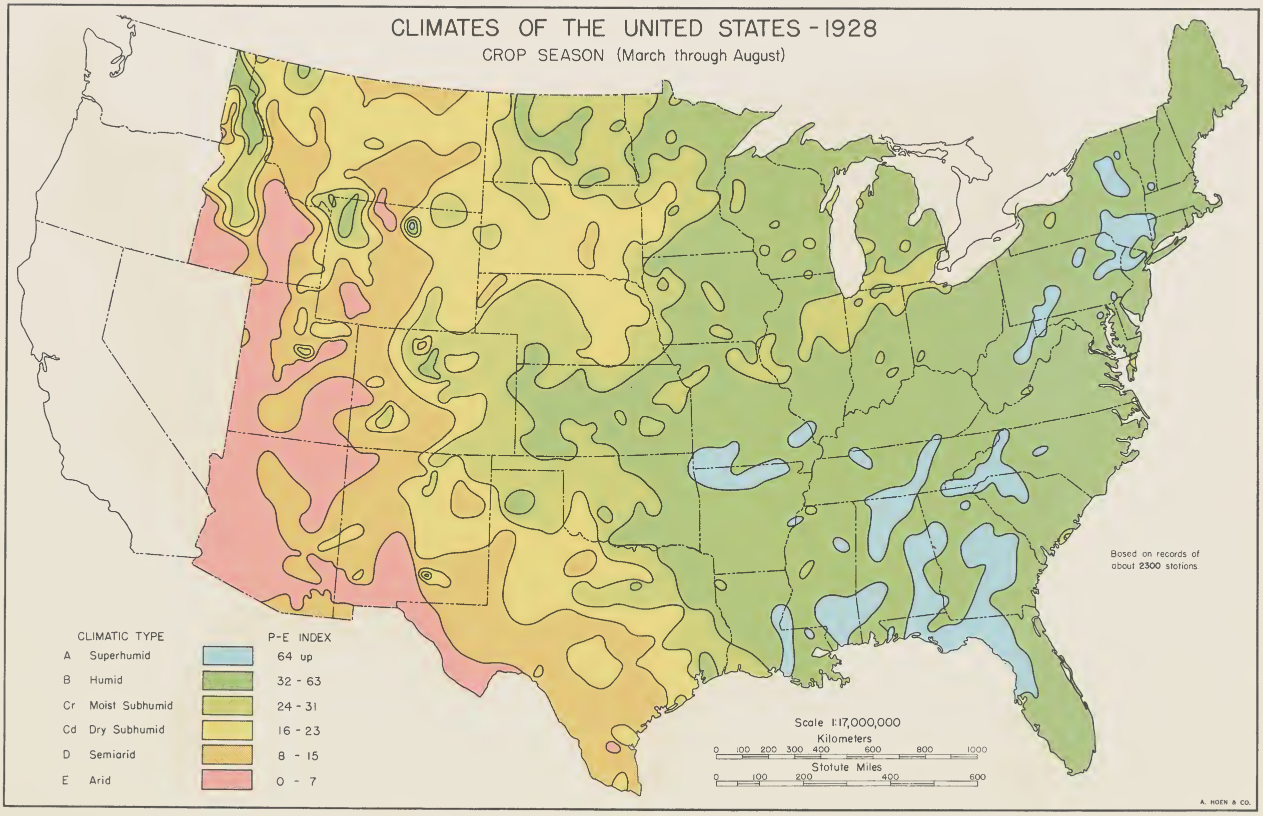
Plate 61



CLIMATES OF THE UNITED STATES - 1928

In 1928 the climates in the area east of the Rockies except for minor irregularities assumed in general their normal pattern. In the West, however, the arid climate was greatly expanded, covering nearly all of Nevada, extending into Oregon and southern Idaho and west to the Pacific in southern California. A single small arid island appeared in east-central Montana. A lobe of moist-subhumid climate extended westward into the Texas Panhandle and dry-subhumid extended entirely across the Plains to the Rockies in two places.

Plate 62

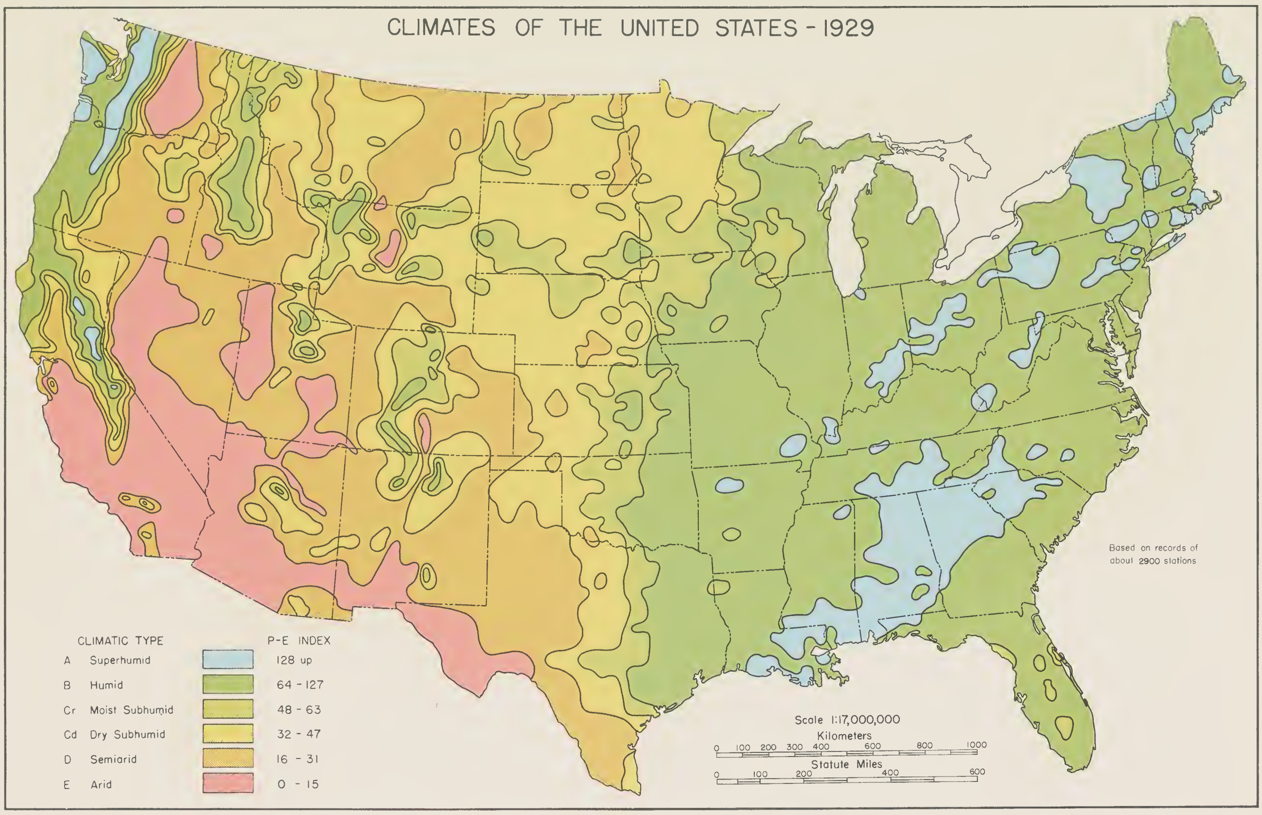


CLIMATES OF THE UNITED STATES - 1928

CROP SEASON (March through August)

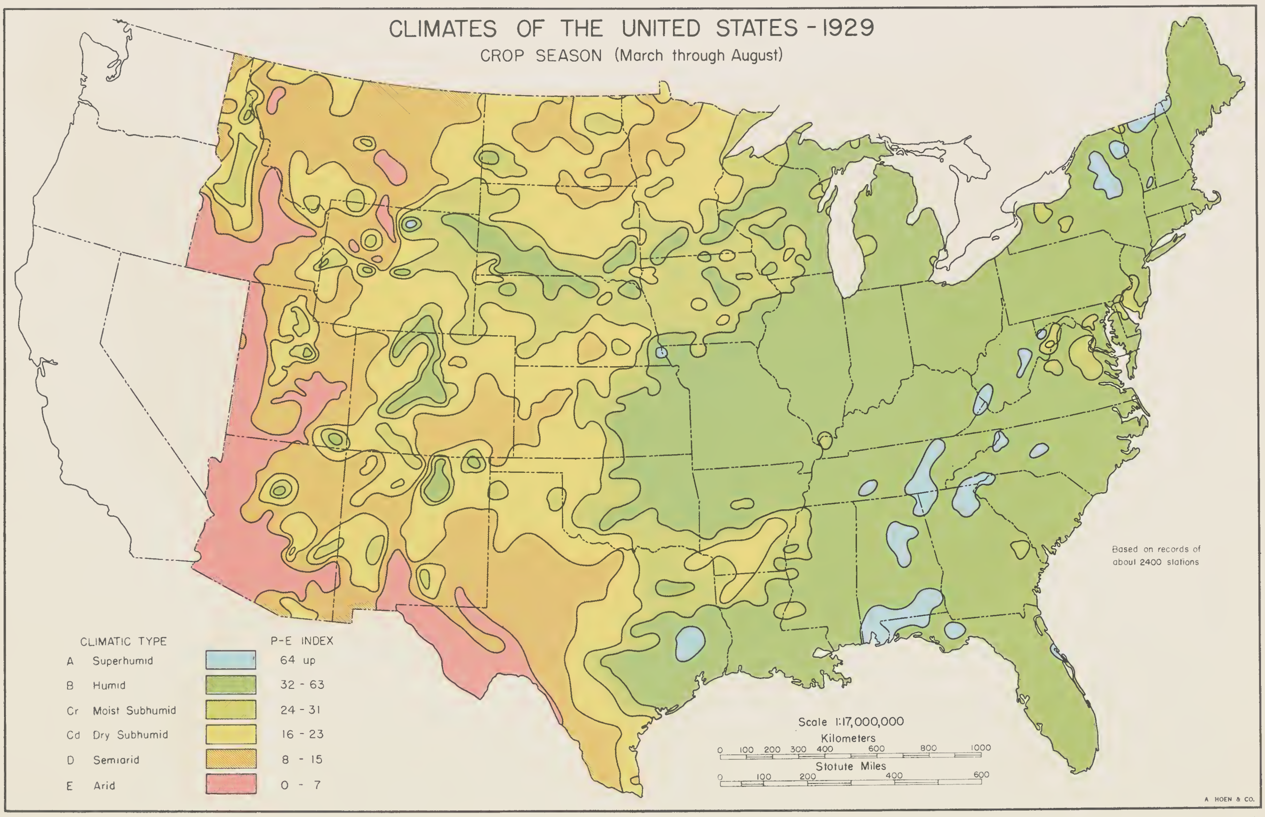
During the crop season of 1928 fairly large superhumid islands appeared throughout the Eastern States. Humid and moist-subhumid climates extended westward across North Dakota and across Kansas and into Colorado. Local variation in climate was well illustrated during the crop season of 1928: North Dakota was more moist; South Dakota and eastern Nebraska drier; Kansas, Oklahoma, and the Texas Panhandle more moist; and south Texas drier than usual.

Plate 63

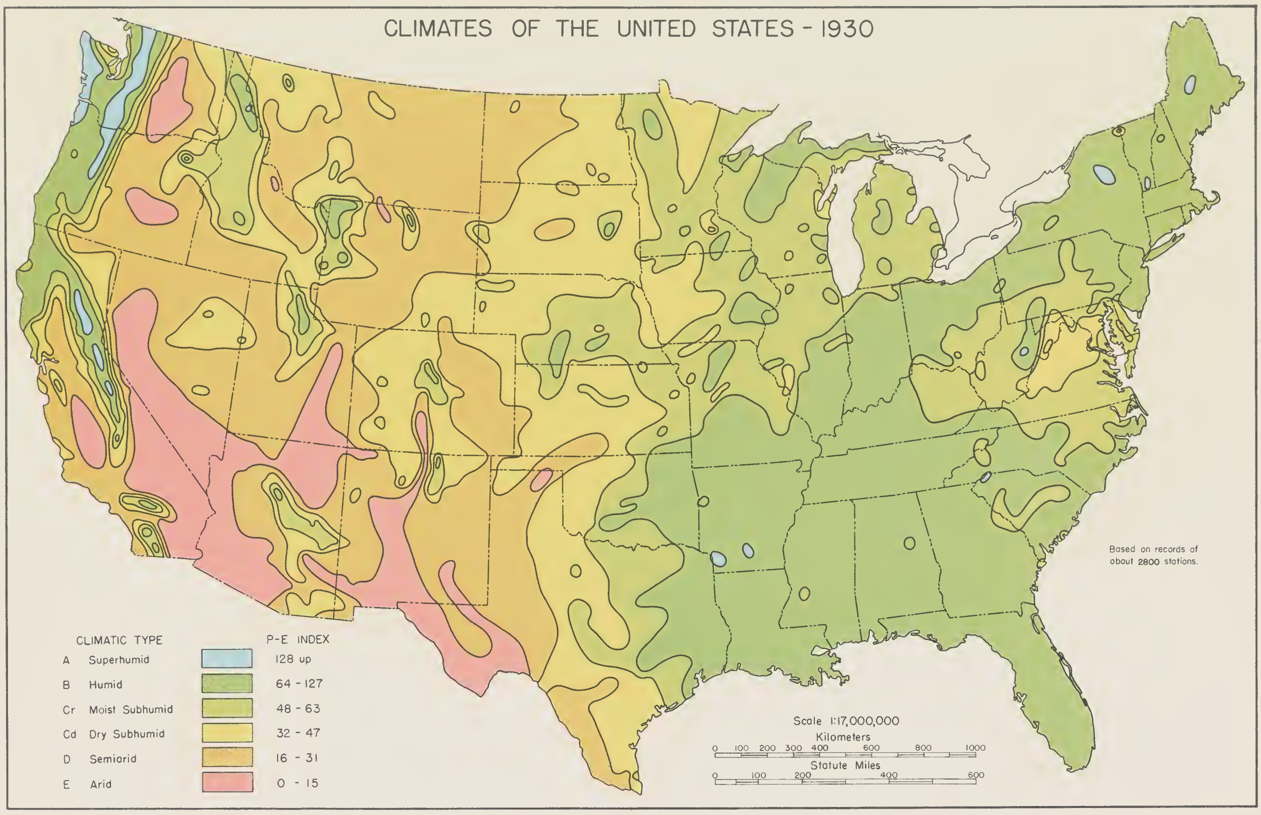


In 1929 superhumid climate was again extensive in the eastern humid region. The largest superhumid area extended from the Mississippi Delta to North Carolina and Kentucky and occupied about half of South Carolina, Georgia, and Alabama. Scattered areas of moist-subhumid climate appeared in the Dakotas, Nebraska, Wyoming, and Montana. Virtually a third of the area of eastern Washington and nearly all of southern California were arid. The possibility of an unusual extent of arid climate in the West and of superhumid climate in the East in the same year is well illustrated.

Plate 64

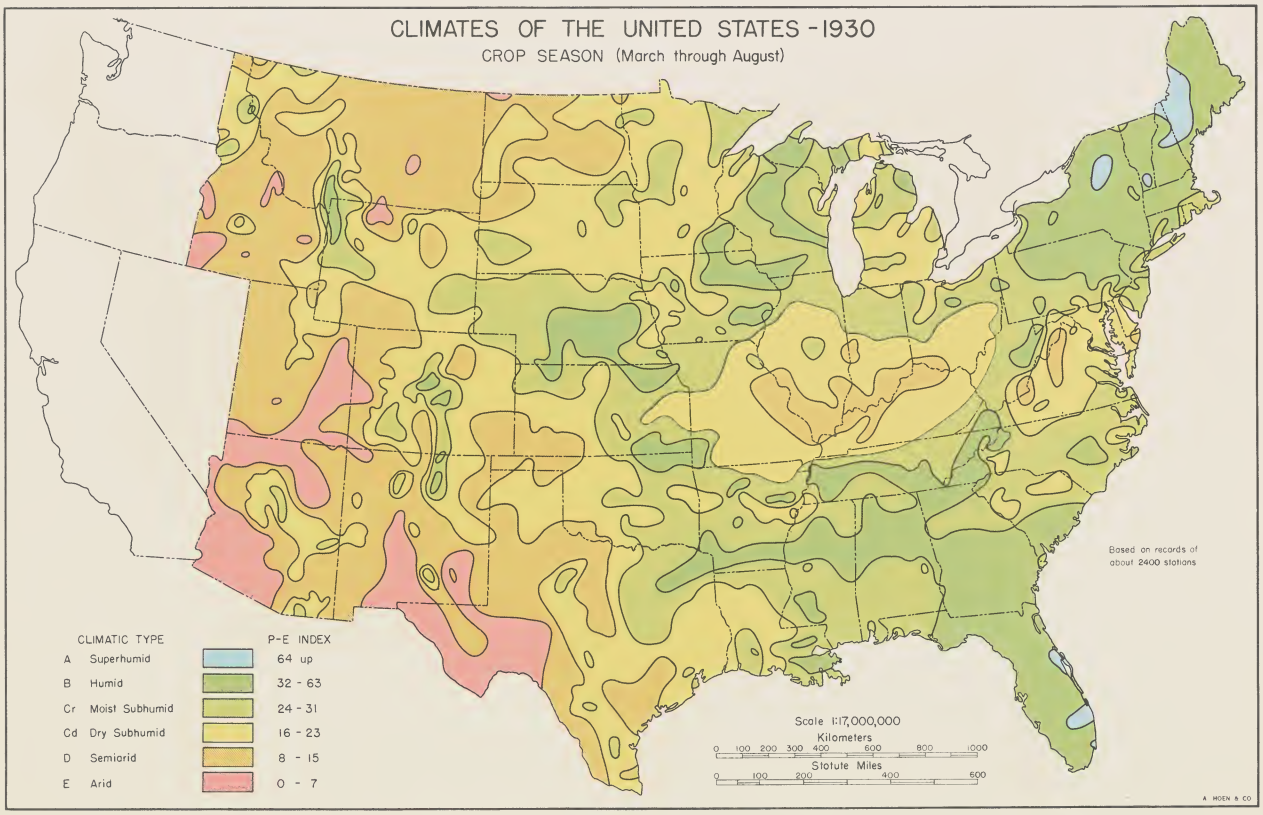


During the crop season of 1929 a number of small superhumid areas appeared along a line between coastal Mississippi and West Virginia, in east Texas, and in northern New York and New England. Extending approximately east and west across the Great Plains and the Middle West were alternating bands of climate moister and drier than usual.



CLIMATES OF THE UNITED STATES - 1930

In 1930 the east-central part of the country suffered its most serious drought. Much of Virginia was dry subhumid and a large surrounding area was moist subhumid. A small semiarid area appeared in eastern West Virginia. The subhumid belts in the Middle West were extremely irregular and moist-subhumid climate pushed eastward across Wisconsin and Michigan. In the West the arid part of eastern Washington was much expanded and a considerable area in eastern Oregon was also arid. A small arid island appeared in the Texas Panhandle.

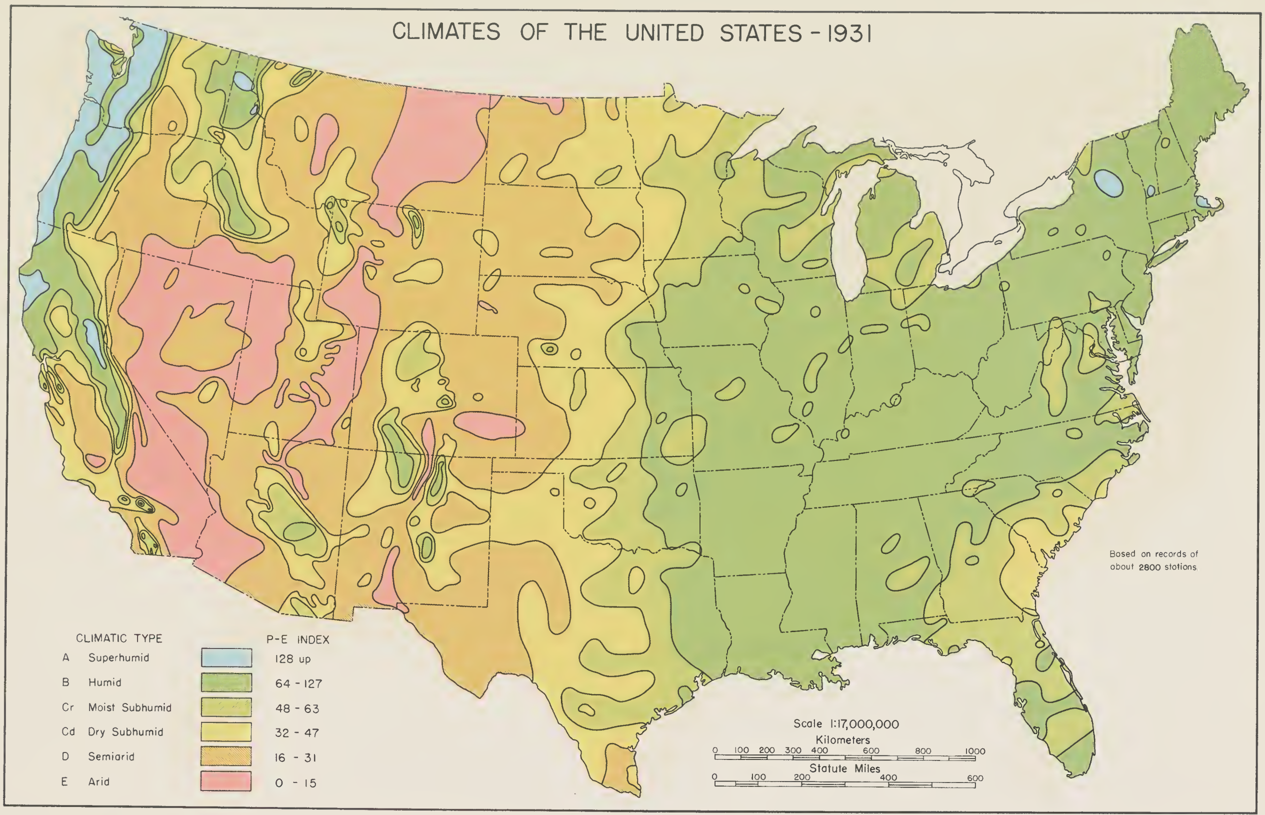


CLIMATES OF THE UNITED STATES - 1930

CROP SEASON (March through August)

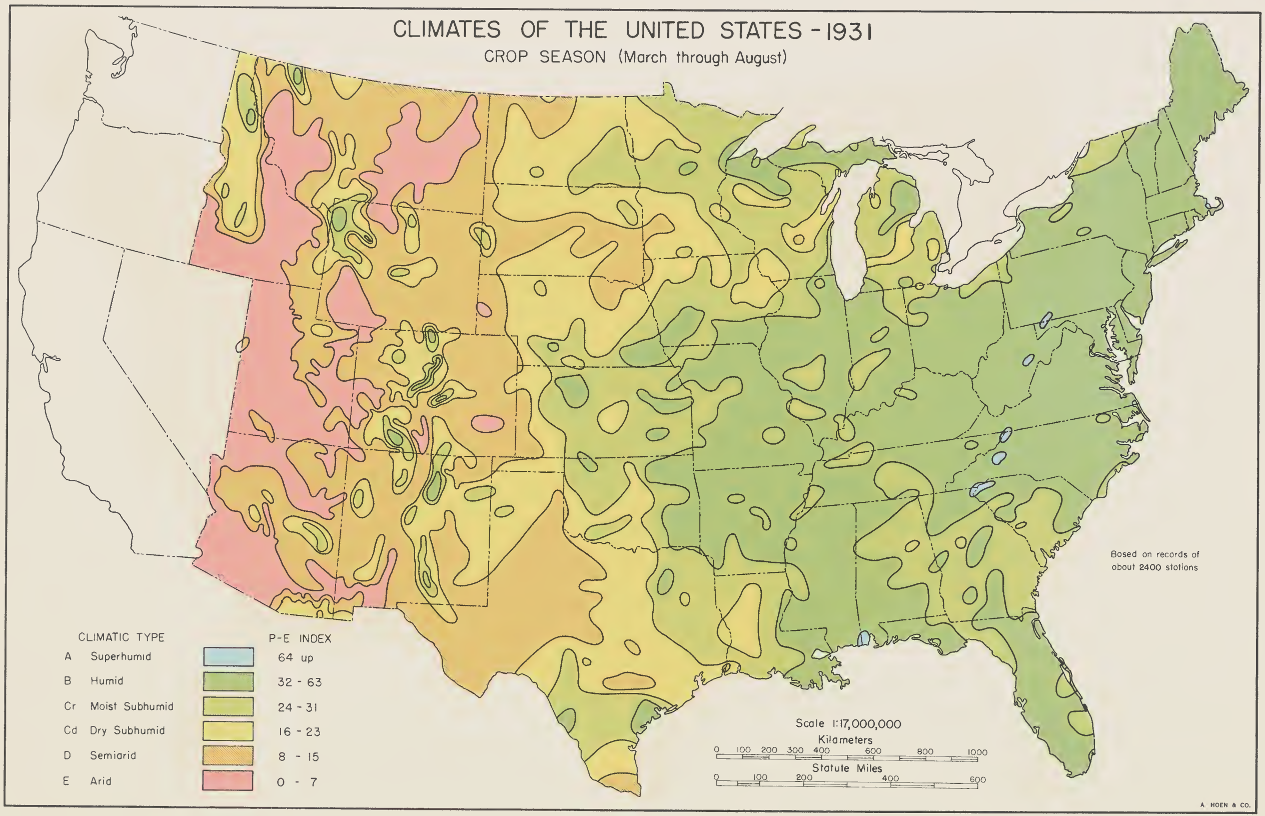
During the crop season of 1930 humid climate was absent, except in the Northeast and the Southeast. A large area in the lower Ohio Valley was semiarid. Three small semiarid islands appeared in West Virginia, Virginia, Delaware, and Maryland. At the same time, nearly all of Nebraska was moist subhumid and humid. The central Plains were more moist than usual, but in the northern and southern Plains semiarid climate was extensive. Small areas in western North Dakota, eastern Montana, and western Texas were arid.

Plate 67



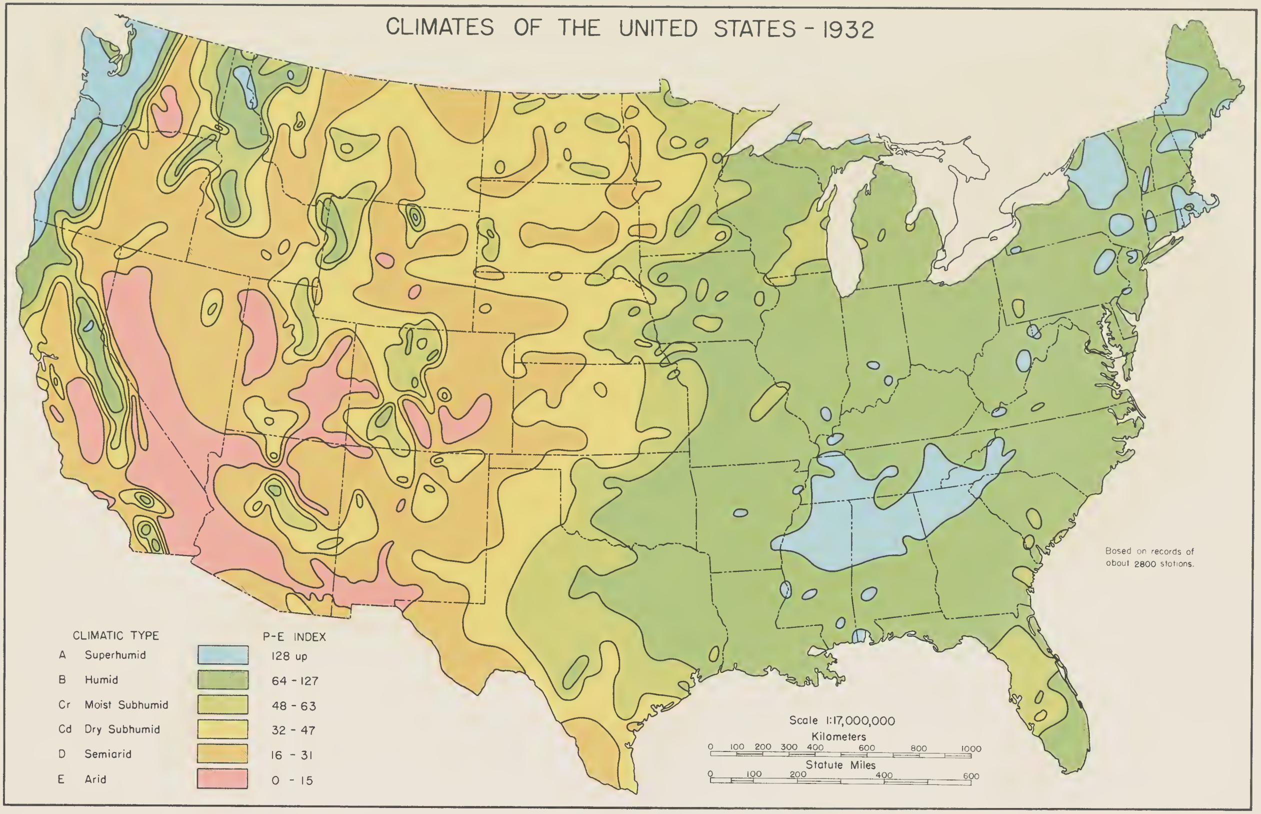
In 1931 the region in eastern United States normally humid was liberally sprinkled with small moist-subhumid areas. In the South Atlantic States a large moist-subhumid area appeared and along the coast of Georgia and the Carolinas was an area of dry-subhumid climate. The area along the Pacific coast was on the whole more moist than usual. The desert area in eastern Washington had disappeared and that in the San Joaquin Valley in California was very much reduced in size. In Texas, New Mexico, and Arizona, the arid areas were also greatly diminished. In the Great Basin area and in the northern and central Great Plains, however, arid climates were unusually extensive. Southeastern Oregon and southern Idaho were arid, as were much of eastern Montana and southeastern Colorado. A small arid area also appeared in western Nebraska.

Plate 68



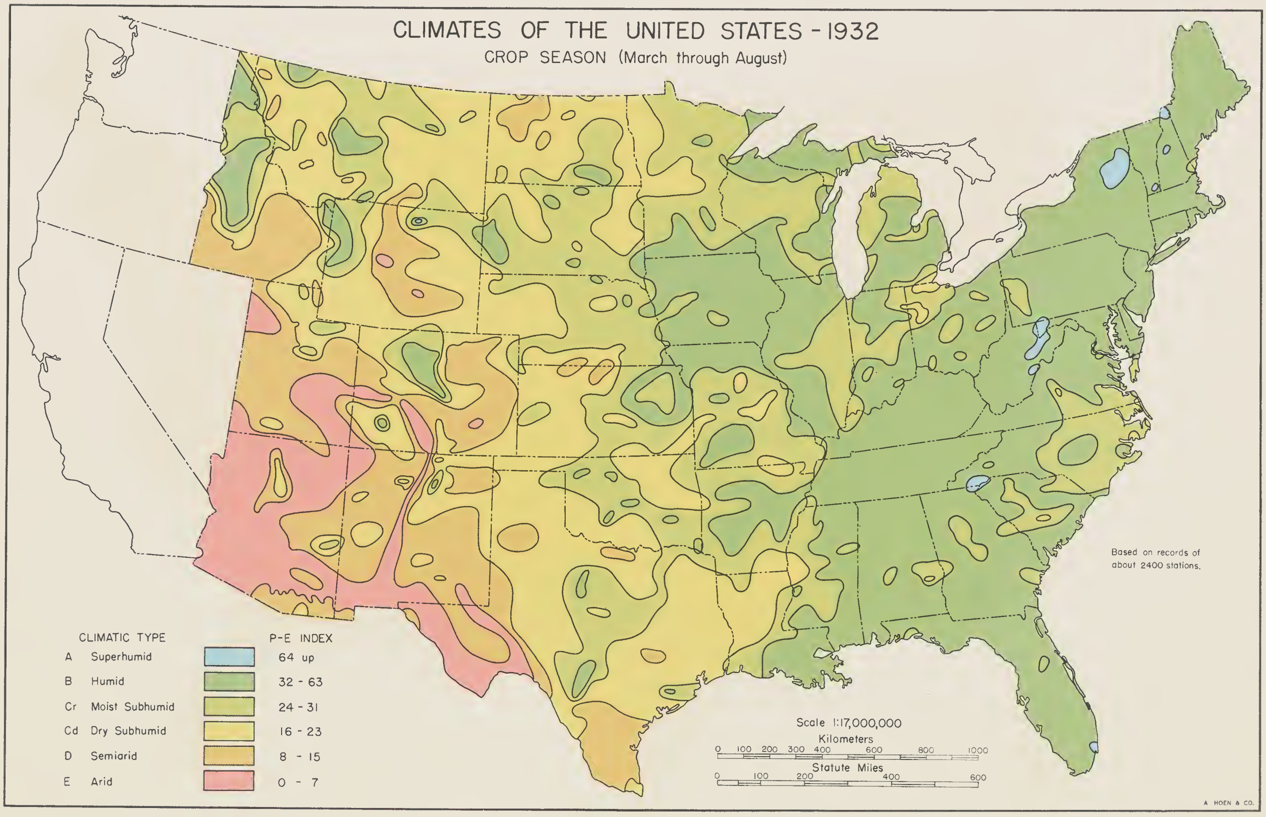
During the crop season of 1931 humid climate in the East was somewhat reduced in extent. A belt from South Dakota, across Wisconsin, and southern Michigan to northern New York was considerably drier than usual and each climatic type was displaced far eastward. The Gulf States also for the most part were abnormally dry. Arid areas were present in Montana, western Nebraska, and southeastern Colorado.

Plate 69



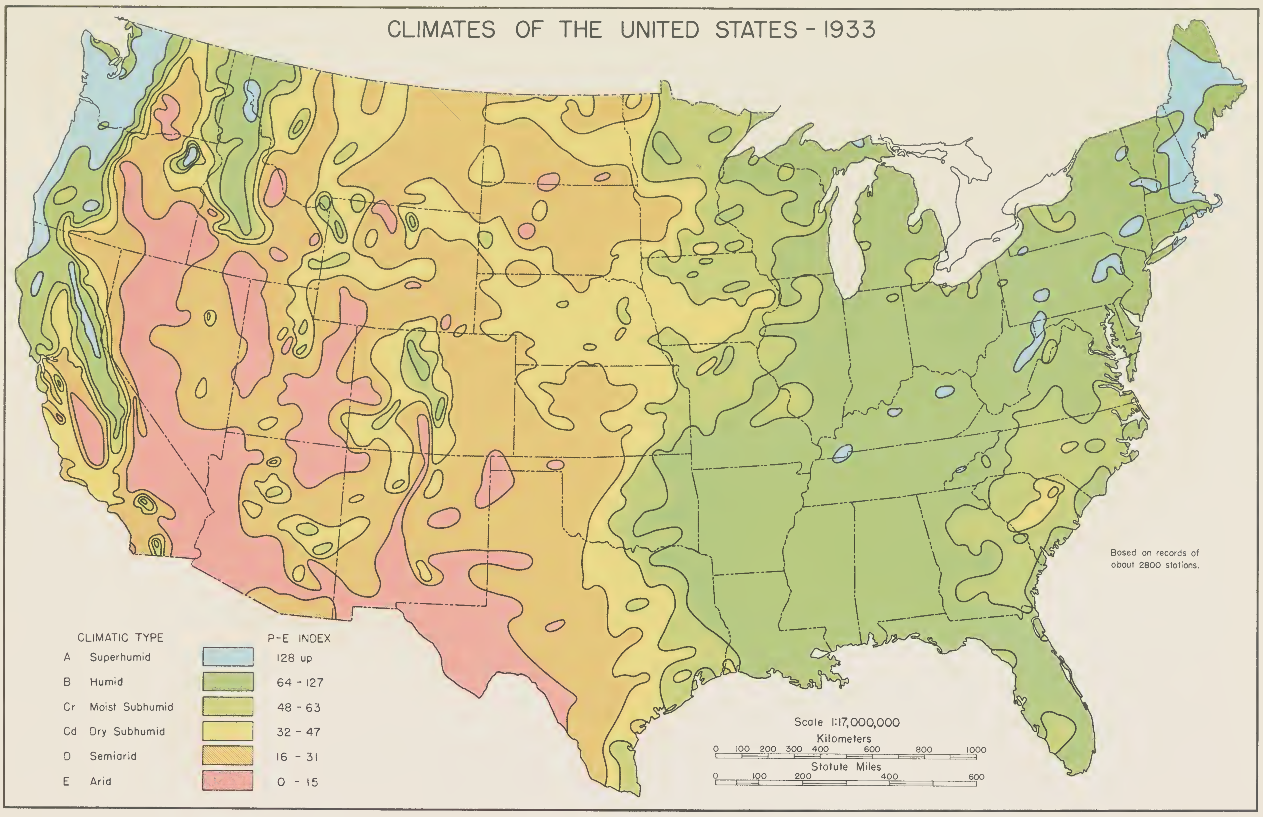
In 1932 a large superhumid area appeared in the Southern States east of the Mississippi and several smaller ones in New England and New York. The humid climate pushed considerably westward in Oklahoma and Texas and in Iowa but was displaced eastward in Missouri and Minnesota. The region normally subhumid and semiarid displayed extremely irregular patterns of climatic distribution. On the whole the northern tier of States was somewhat more moist than usual, but a large arid area appeared in eastern Colorado and two small ones in central Wyoming. The part of California normally subhumid was largely semiarid.

Plate 70



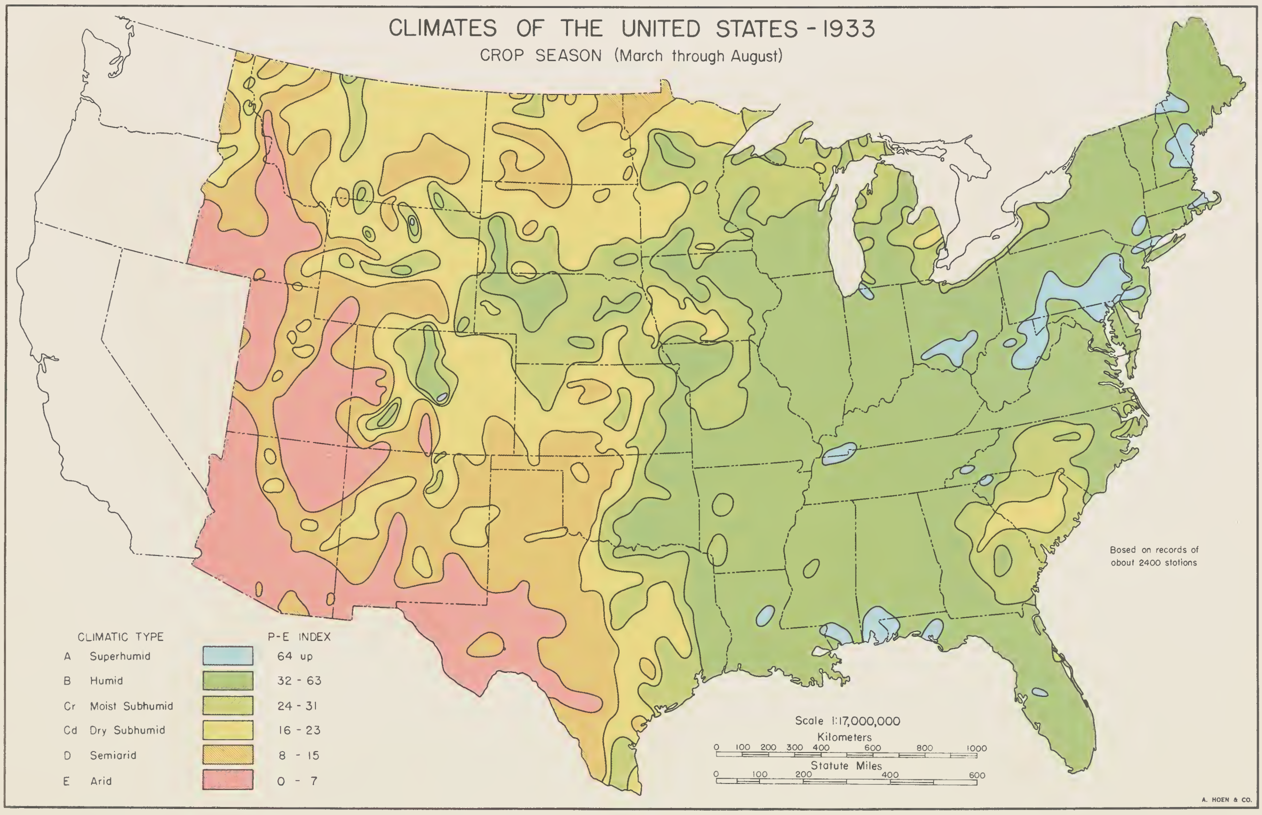
During the crop season of 1932 the climatic distribution was extremely irregular throughout most of the country. Subhumid areas were extensive in the normally humid East.

Plate 71

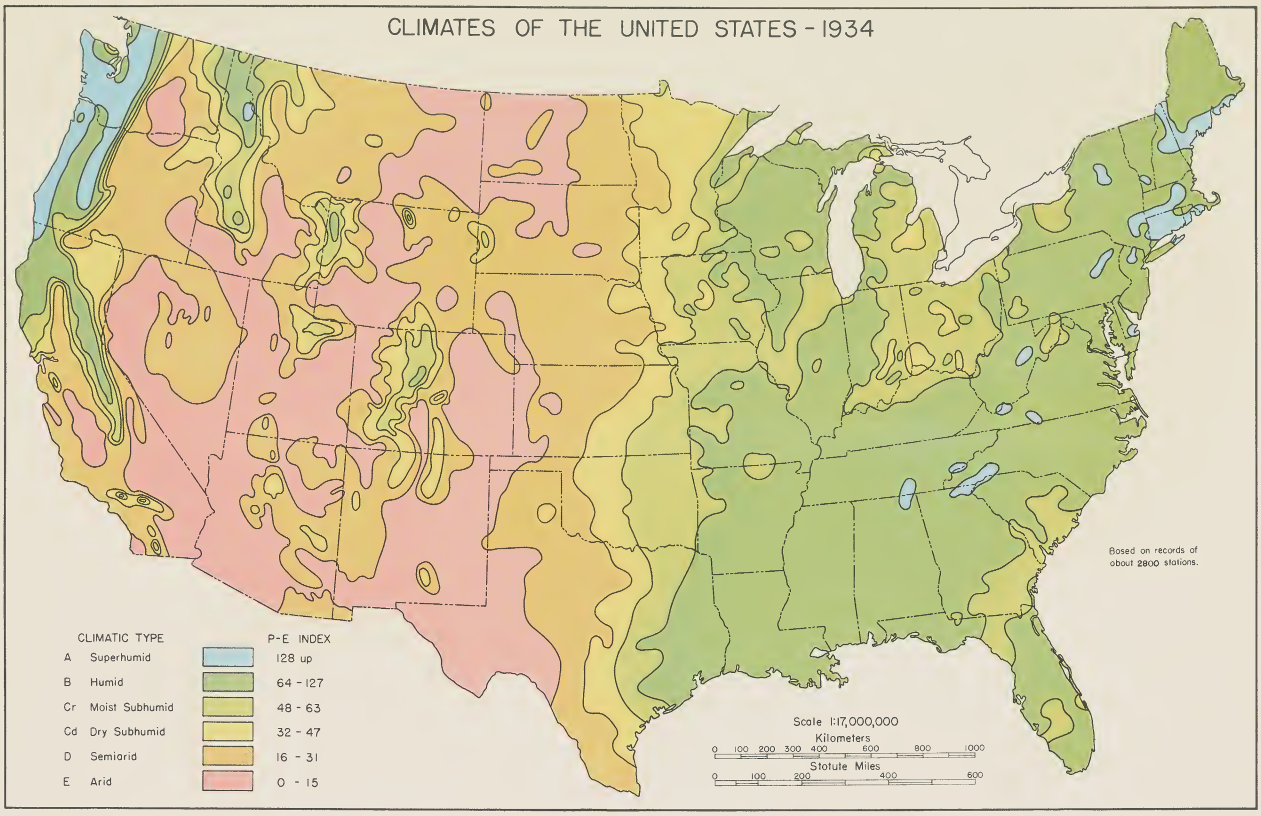


In 1933 subhumid climates again appeared in the South Atlantic States. Scattered small islands of superhumid climate appeared in the Ohio Valley and the Northeast. In general, the semiarid climate of the Plains was extended considerably to the east and arid climates were nearly everywhere expanded. A number of small islands of arid climate appeared in the Great Plains, notably in North Dakota, South Dakota, eastern Wyoming, the Oklahoma and Texas Panhandles, eastern New Mexico, and west Texas.

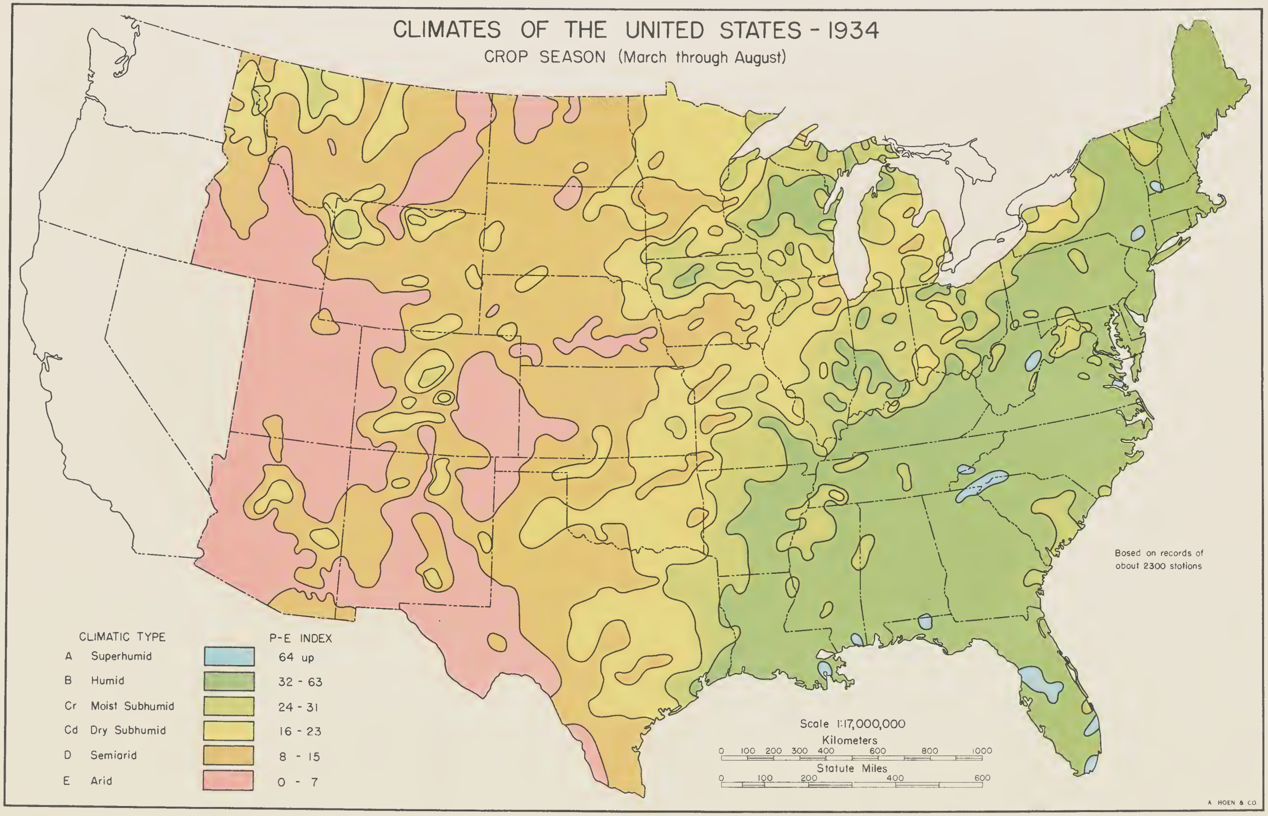
Plate 72



During the crop season of 1933 much of the Carolinas and Georgia was subhumid. Moist-subhumid and humid climates pushed westward across Nebraska and the southern part of South Dakota into Wyoming and Montana. In Oklahoma and Texas semiarid climate pushed eastward and the belts of moist and dry subhumid were usually narrow. Much of west Texas was arid. Superhumid climate appeared in Ohio, Pennsylvania, West Virginia, New England, and the Gulf coast.

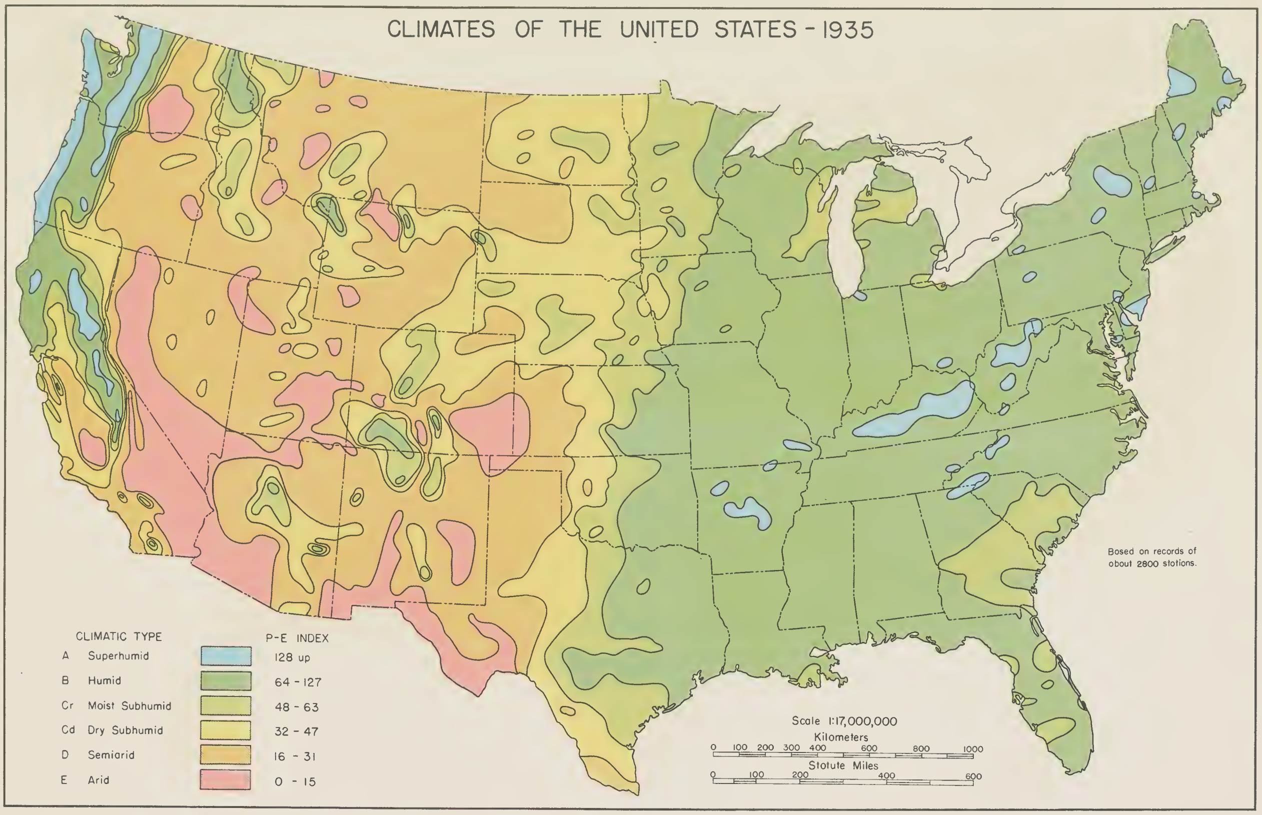


In 1934 the areas of arid and semiarid climates were greatly enlarged. Arid climate extended continuously from the Mexican border in Arizona and California to the Canadian border in North Dakota and Montana. Fully half of the area of North Dakota was arid, as was much of South Dakota and eastern Montana and nearly all of the Great Plains area from Nebraska southward. There was a considerable eastward displacement of semiarid climate except in south Texas. The two subhumid belts were much narrower than usual. A large subhumid area occupied most of Ohio, lower Michigan, eastern Indiana, and northern Kentucky. Subhumid climate extended from the Florida Gulf coast across the peninsula and along the coasts of Georgia and South Carolina. Small superhumid islands occurred along a line from Mississippi to Maine.



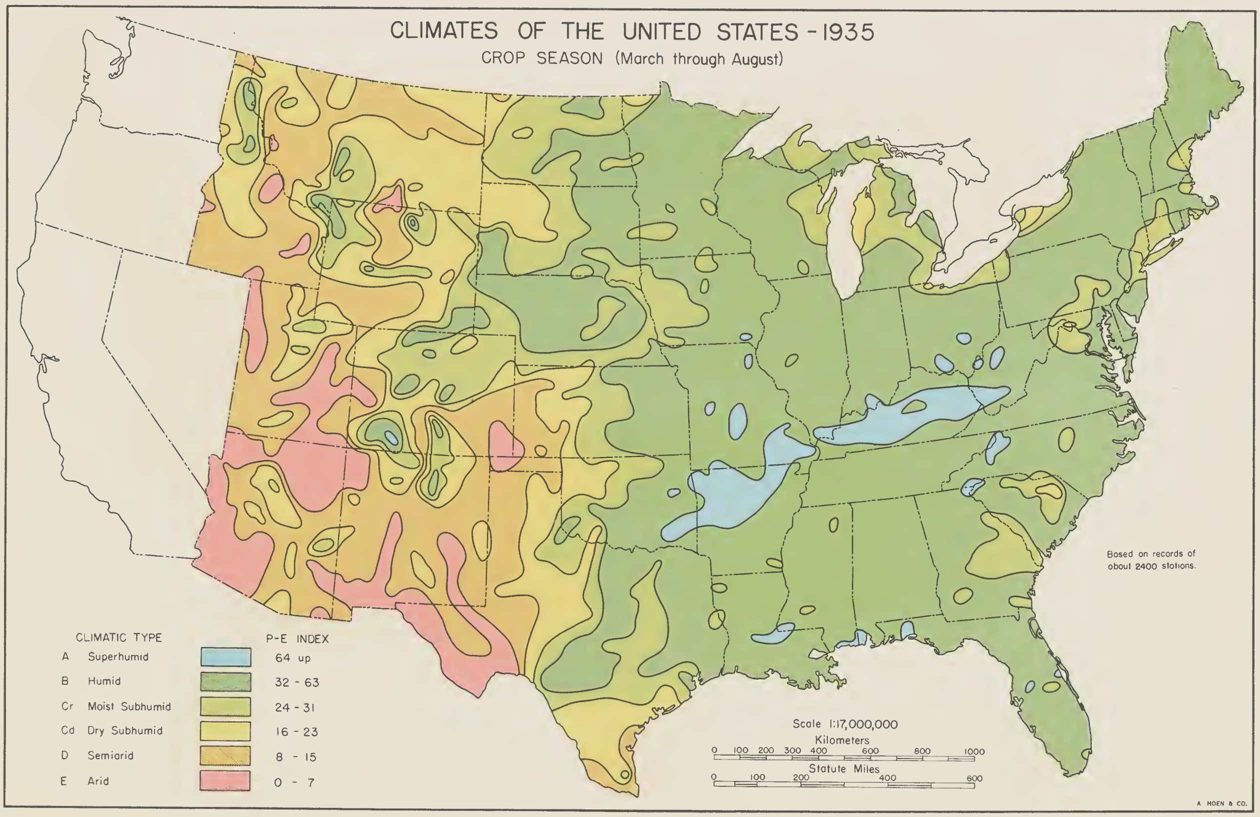
During the crop season of 1934 virtually the entire interior of the continent as far eastward as New York suffered from serious drought. Huge arid areas appeared in the central and northern Great Plains and eastward in the prairies of eastern Nebraska and north central South Dakota. The subhumid belts were extremely irregular.

Plate 75



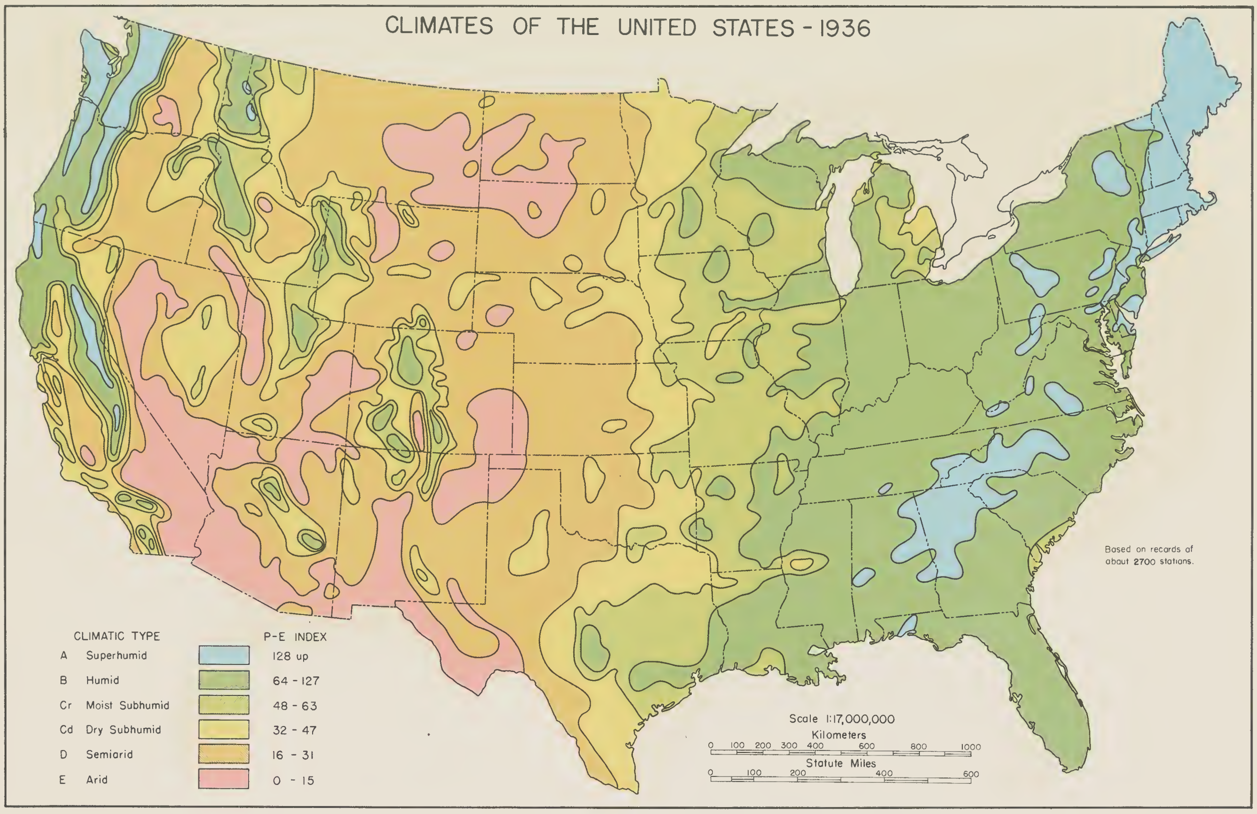
In 1935 the humid area of the East was extended considerably westward. Throughout the western part of the country there appeared numerous islands of arid climate, the largest of which embraced parts of southeastern Colorado, western Kansas, northeastern New Mexico, and the Oklahoma and Texas Panhandles. Across Kansas and Oklahoma the subhumid climatic belts were very narrow. Several arid areas appeared in western Montana. Small superhumid areas were numerous along a line from Arkansas to Maine. Parts of South Carolina, Georgia, and Florida were moist subhumid.

Plate 76



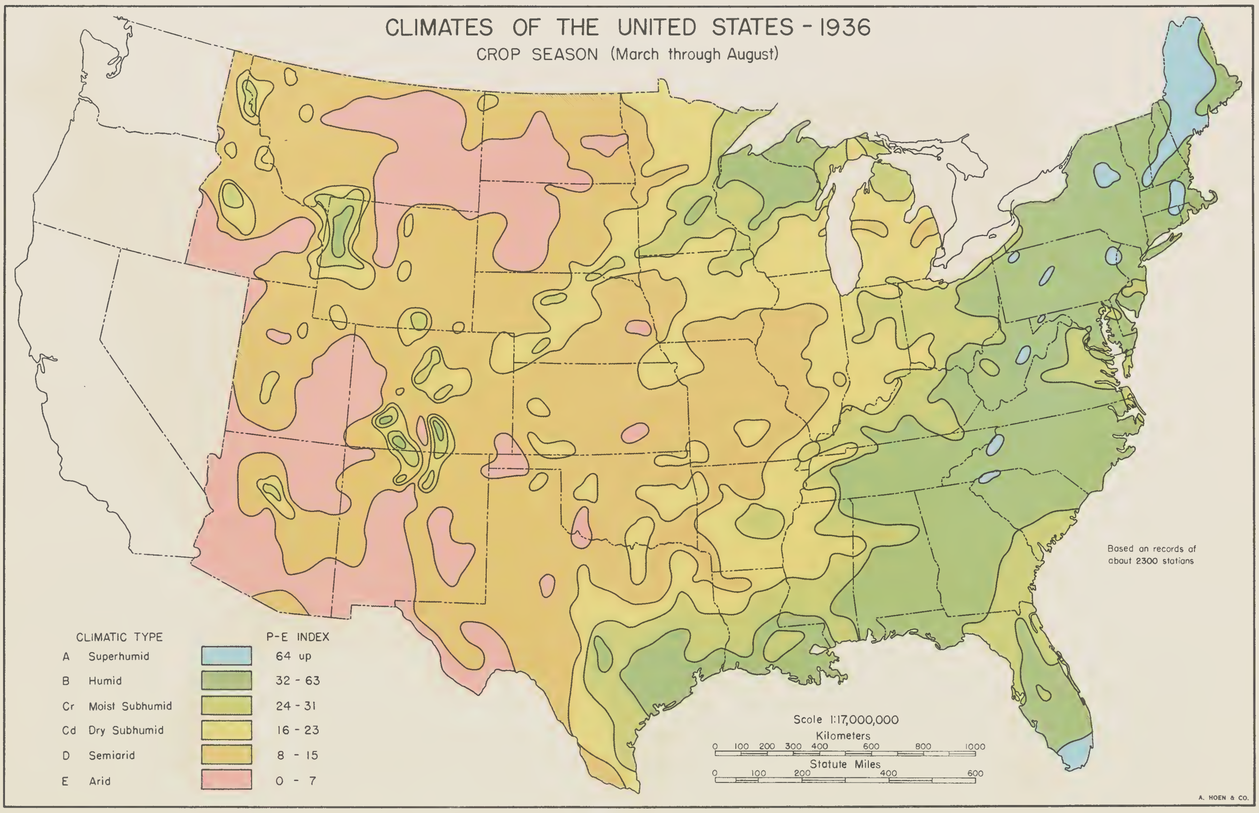
During the crop season of 1935 humid climate was considerably extended, particularly in the North. Superhumid areas covered large parts of Kentucky, Arkansas, and parts of Missouri and Oklahoma. The western end of the Oklahoma Panhandle and parts of the neighboring States were arid. Sharp contrasts appeared from west to east in Oklahoma and from south to north in eastern Colorado. A number of isolated subhumid areas appeared in the Atlantic Coast States and the Lake States.

Plate 77



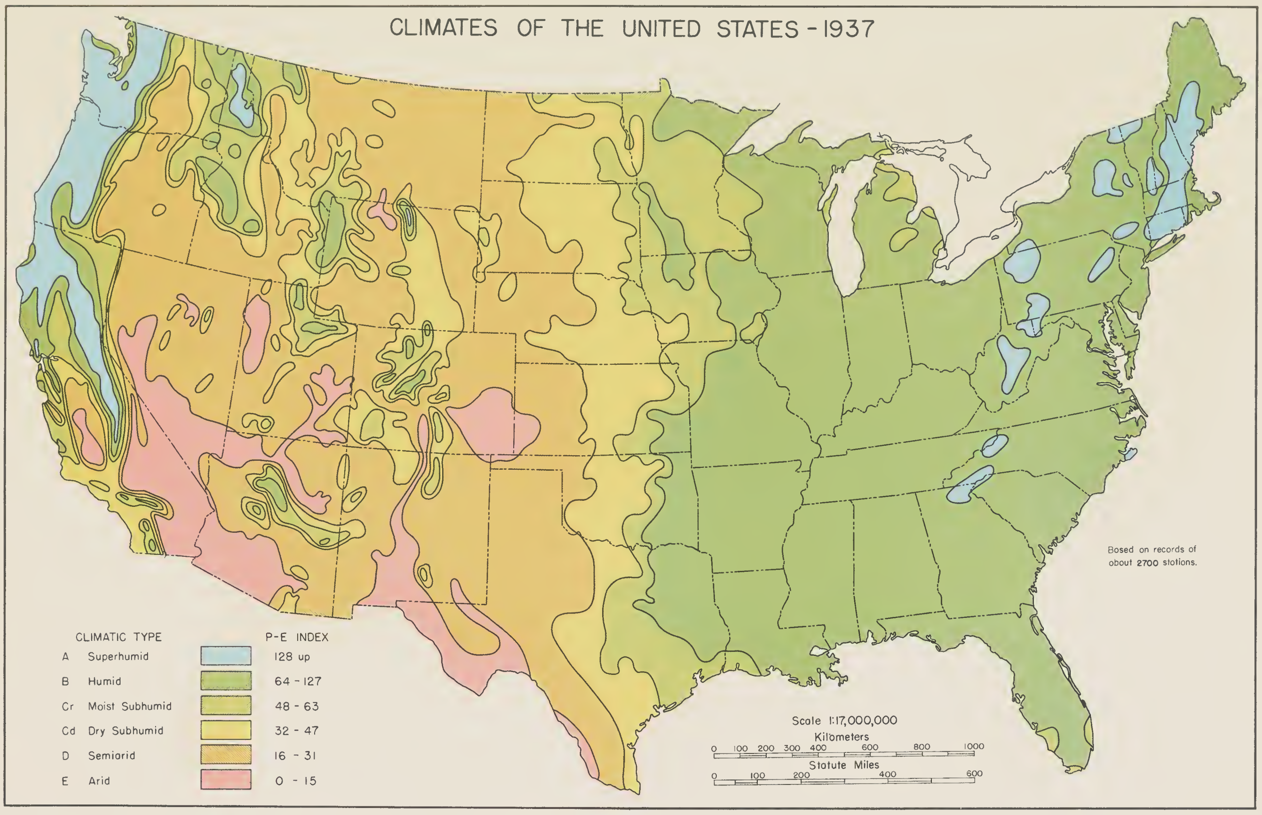
The year 1936 was one of strong contrasts. In the Eastern States superhumid climates were very extensive, whereas arid climates were extensive in the Great Plains. The humid area was considerably smaller than usual, and the moist-subhumid belt was displaced eastward into Arkansas, Missouri, and Wisconsin, and was very irregular. A small area of dry subhumid appeared in the lower peninsula of Michigan. The semiarid area was extended far to the east from the Great Plains. Large areas in North Dakota, South Dakota, and Montana were arid. There was a large arid area in southeastern Colorado, western Kansas, northeastern New Mexico, and the Oklahoma and Texas Panhandles, and smaller areas in Wyoming, western Nebraska, and northeastern Colorado.

Plate 78



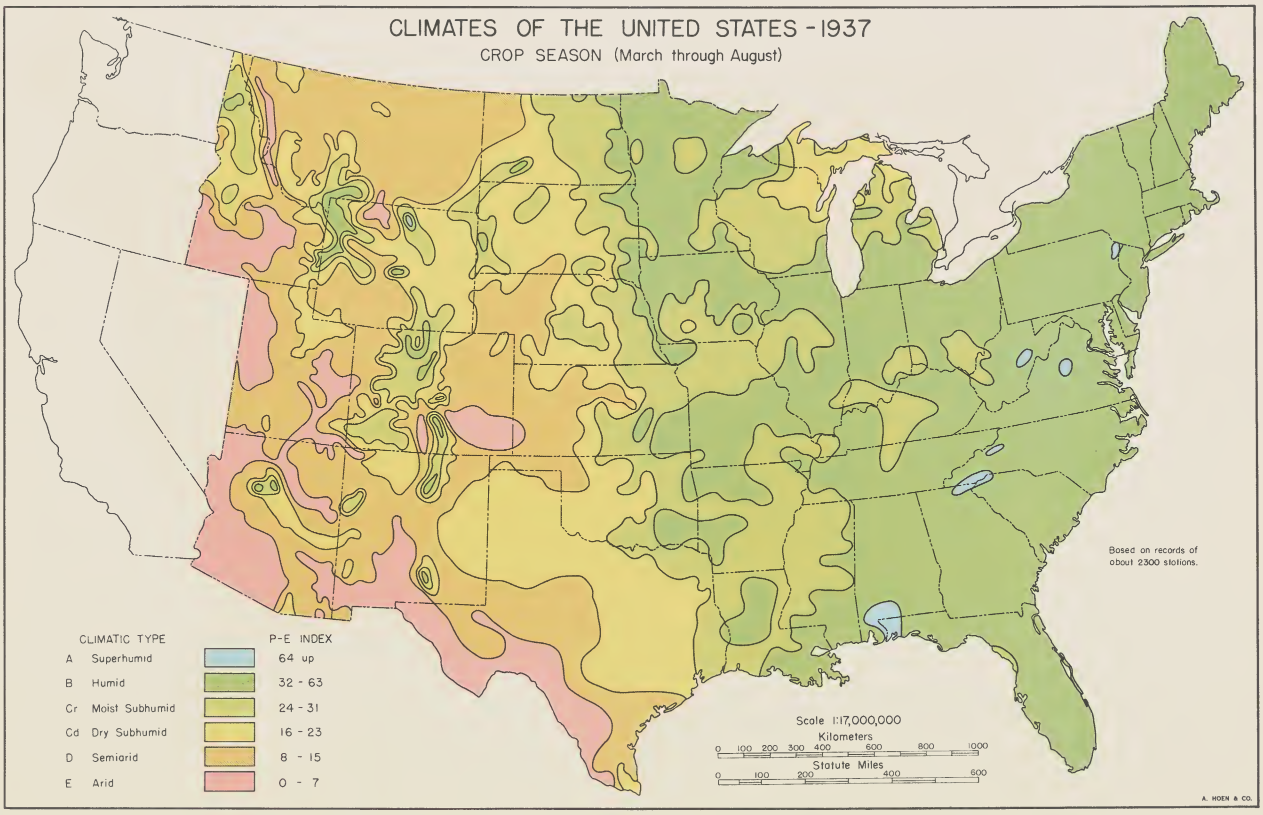
During the crop season of 1936 semiarid climate pushed eastward into Illinois, Wisconsin, and Michigan. Approximately half of the area of North Dakota, South Dakota, and Montana was arid. Small arid islands appeared in eastern North Dakota, eastern Nebraska, and eastern Kansas, and in western Oklahoma and western Texas. Superhumid islands were present from western South Carolina to Maine and in the southern tip of Florida. Several small areas along the Atlantic coast were moist subhumid.

Plate 79



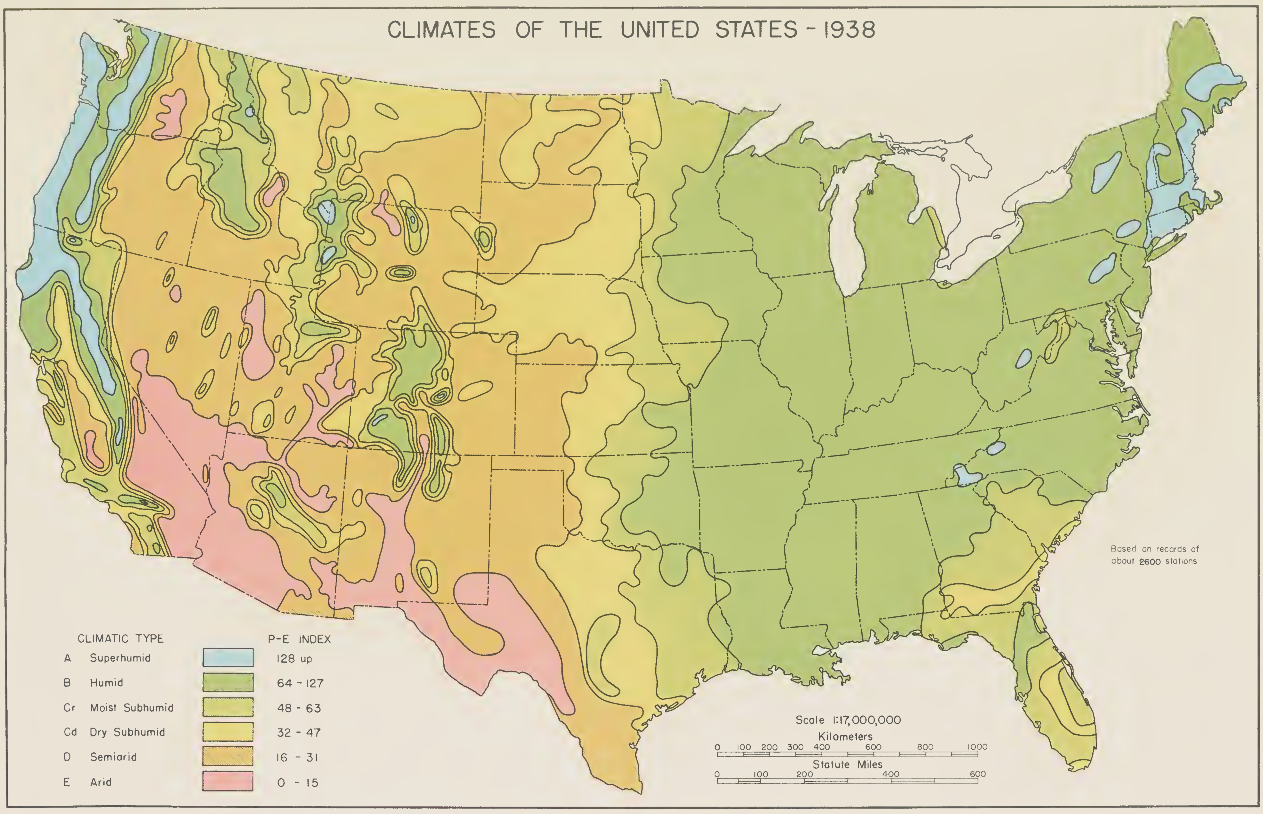
In 1937 the distribution of climate throughout the United States was fairly close to normal. Superhumid climate was somewhat more extensive than usual in the Northeast and in the Pacific Northwest. The arid areas in eastern Washington were missing and those in Nevada and Utah were somewhat restricted. However, the large arid area in southeastern Colorado, western Kansas, northeastern New Mexico, and the Oklahoma Panhandle reappeared for the eighth consecutive year. The moist-subhumid belt was very narrow.

Plate 80



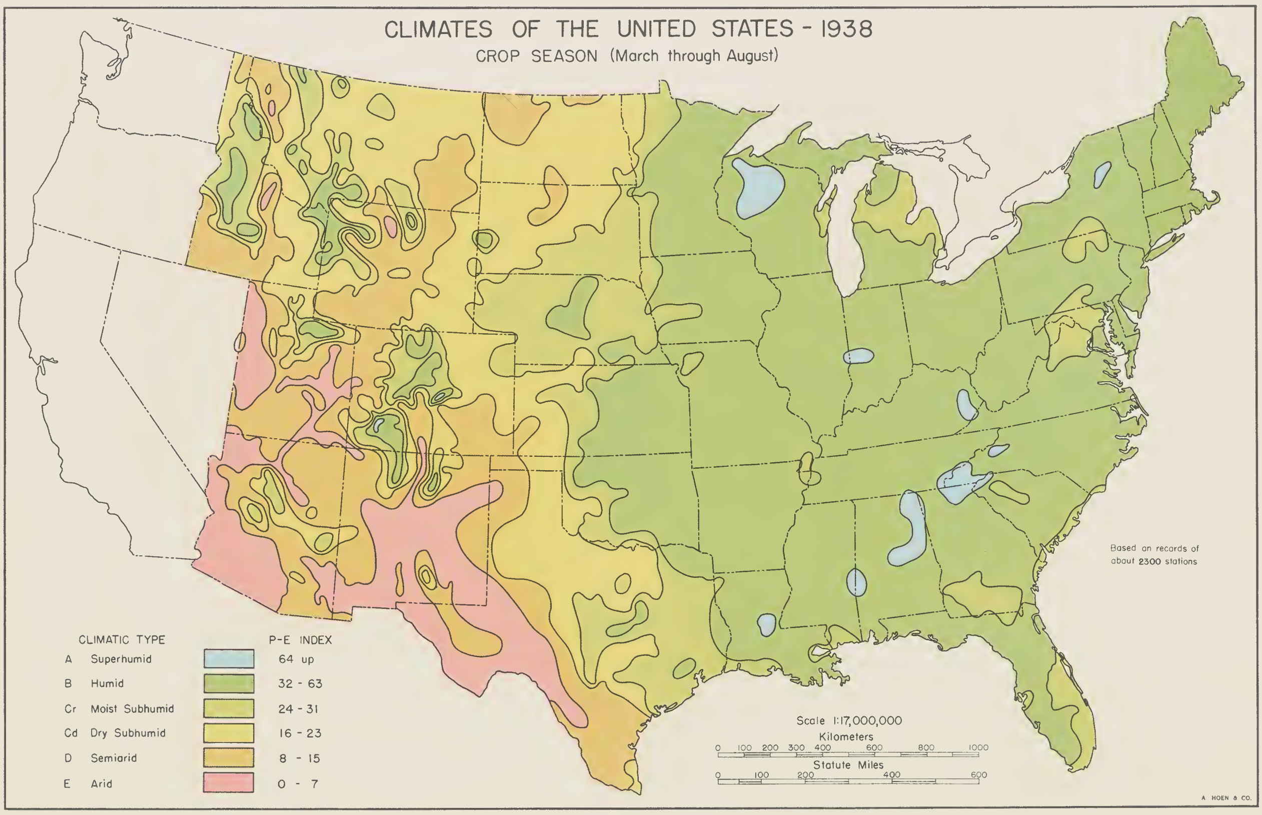
During the crop season of 1937 the climatic distribution was irregular with lobes and islands of subhumid climate extending far eastward into the normally humid region. Wisconsin and both peninsulas of Michigan were moist subhumid and dry subhumid. Much of the lower Mississippi Valley and several areas in the lower Ohio Valley were moist subhumid. The arid area persisted in southeastern Colorado and western Kansas.

Plate 81


CLIMATES OF THE UNITED STATES - 1938

In 1938 much of New England was again superhumid. The arid area in western Texas was somewhat enlarged, whereas that in Nevada was less extensive. Semiarid climate moved eastward beyond the Great Plains except in Nebraska, where a dry-subhumid lobe extended west into Wyoming. Southeastern Minnesota and much of Iowa, normally moist subhumid, were humid. Most of Florida and parts of South Carolina, Georgia, and Alabama were subhumid.

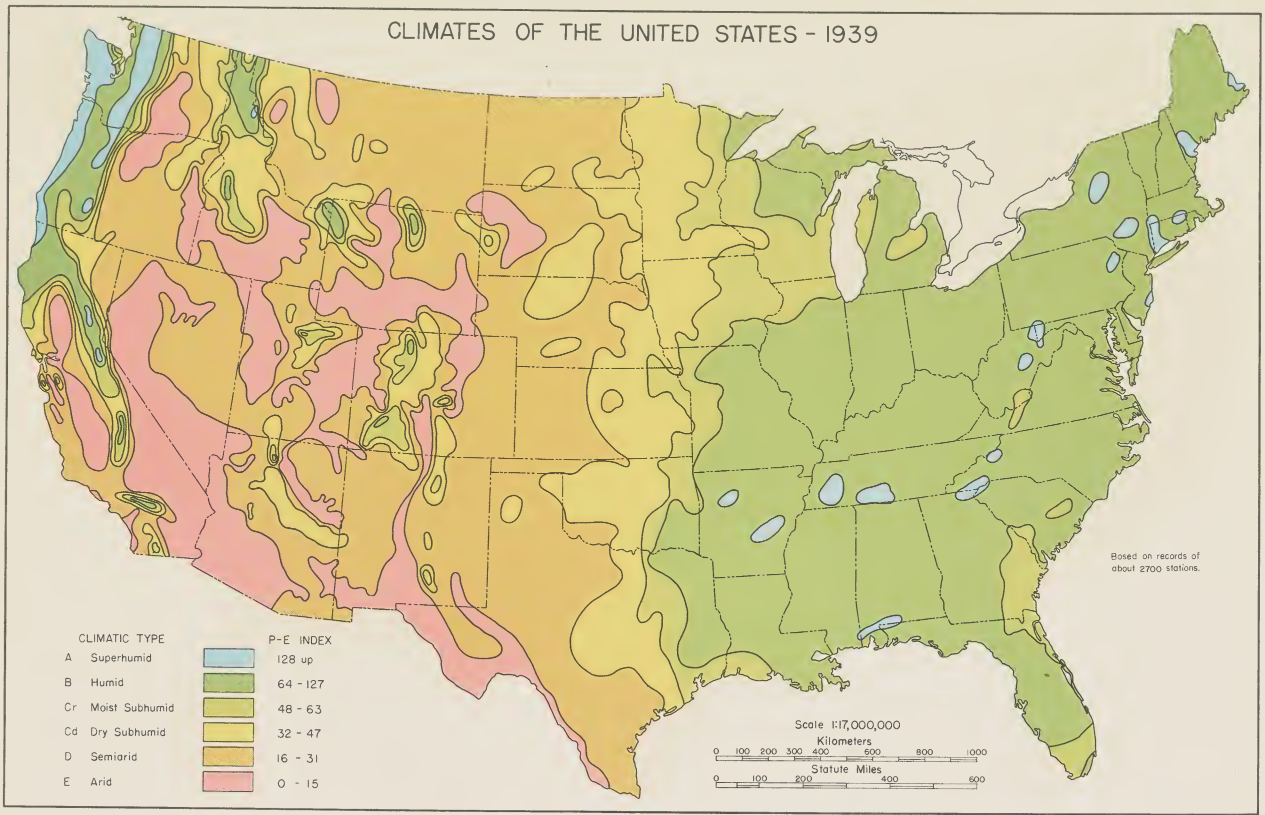
Plate 82


CLIMATES OF THE UNITED STATES - 1938

CROP SEASON (March through August)

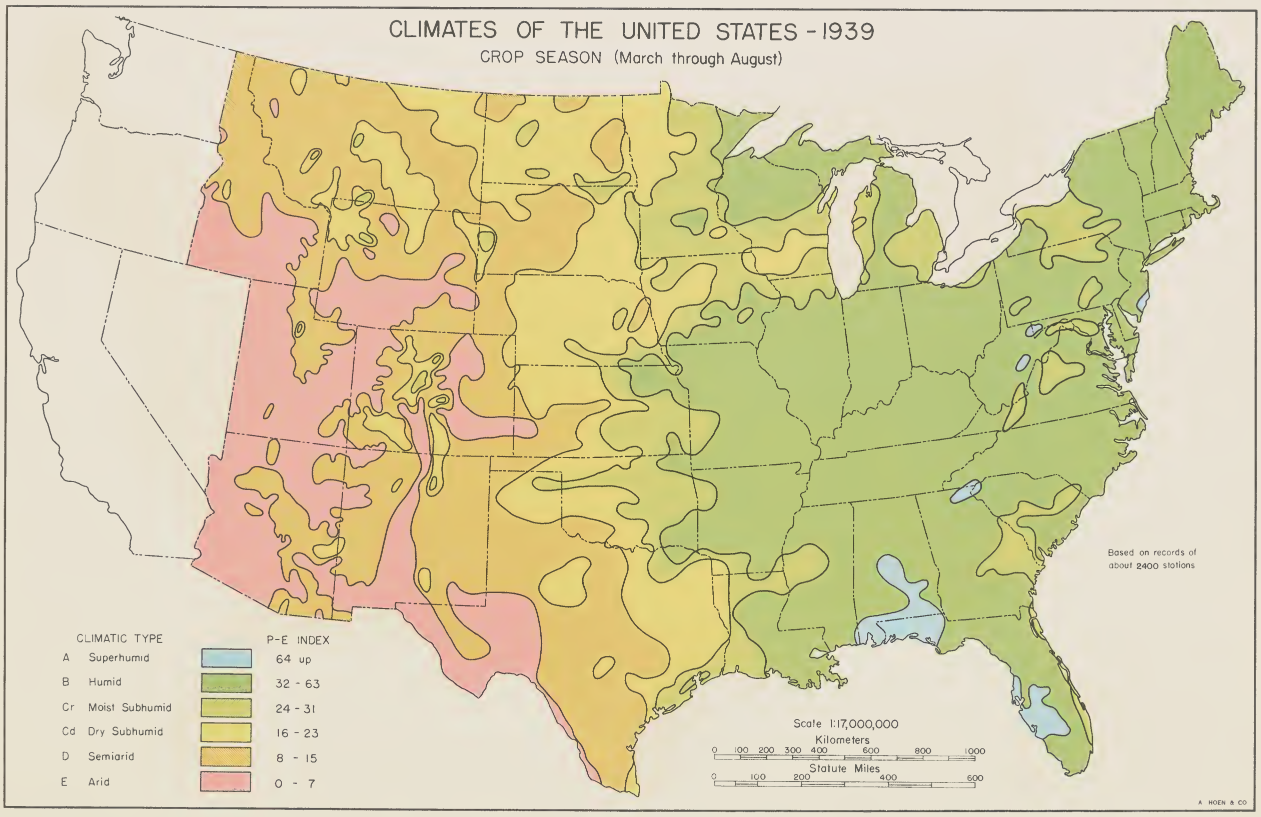
During the crop season of 1938 humid climates occupied approximately their normal distribution, except where they extended westward into western Oklahoma and Kansas. A superhumid area appeared in northwestern Wisconsin and several others were present in the Southeast. There were several moist-subhumid islands in the Eastern States. A moist-subhumid lobe extended across Nebraska into eastern Wyoming and northeastern Colorado. Much of southeastern New Mexico and west Texas was arid.

Plate 83



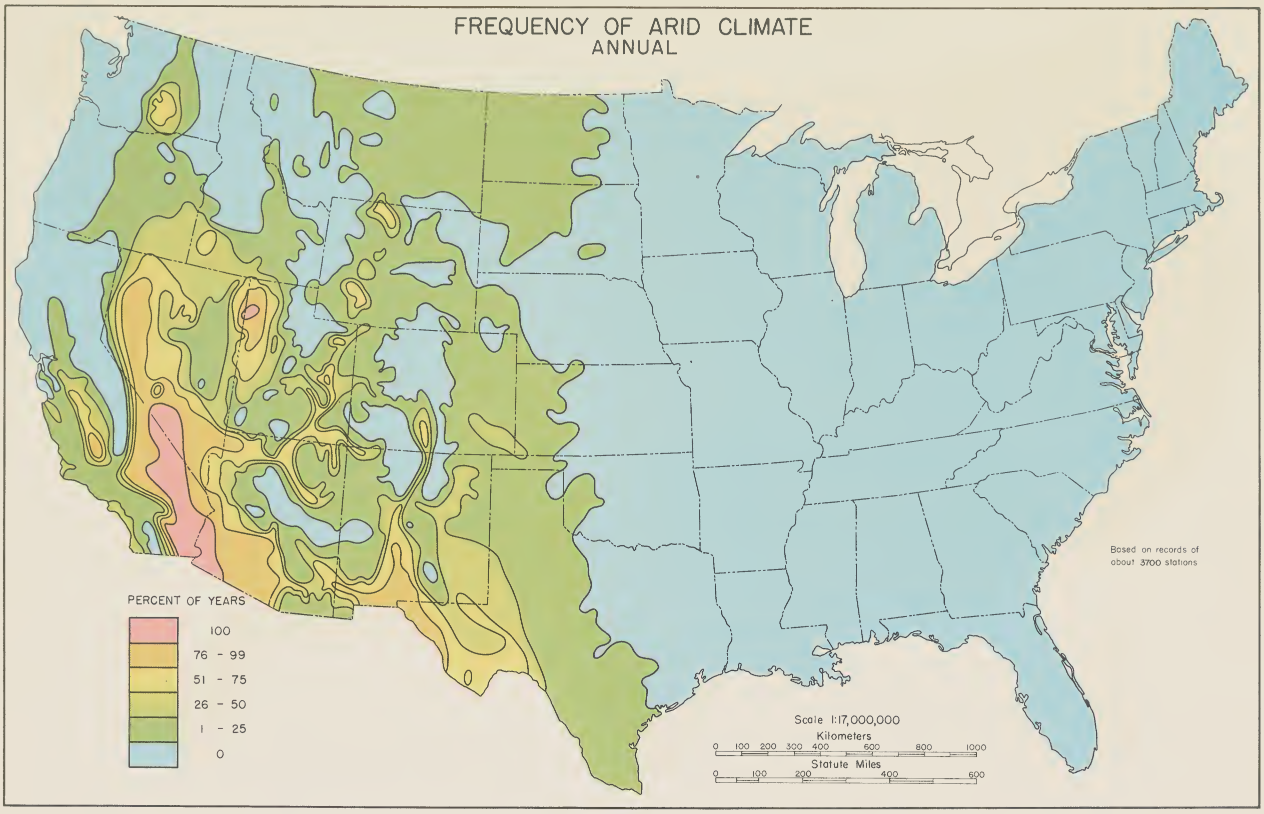
In 1939 the humid area in the eastern United States had approximately normal extent. It contained numerous widely scattered superhumid islands. Arid and semiarid climates were unusually extended; both moist-subhumid and dry-subhumid belts were narrower than usual and were displaced eastward, especially in Wisconsin and Minnesota. The arid area of eastern Washington was much enlarged and reached far south into Oregon. Similarly, the arid area normally limited to western Utah continued northward and covered most of southern Idaho and part of eastern Oregon. Arid climate occupied most of southern Wyoming and extended southward in Colorado east of the Rockies. Western South Dakota had a large arid area and northwestern Montana, two smaller ones. Arid climate prevailed through most of the Sacramento and San Joaquin Valleys and in several of the coastal valleys of southern California.

Plate 84



During the crop season of 1939, humid climate in the East was considerably reduced in area. A lobe of subhumid climate extended eastward into Michigan and reappeared as a large island in central New York, and there were a number of subhumid islands in the Atlantic Coast States. Superhumid islands were present along the Gulf coast of Florida and Alabama. The moist-subhumid belt was markedly irregular and narrower than usual. Arid climate was more extensive than usual in west Texas, southern Wyoming, and southern Idaho. A large arid area appeared in eastern Colorado and western Kansas. Lobes of semiarid climate extended far eastward in South Dakota, Kansas, and Texas.

Plate 85

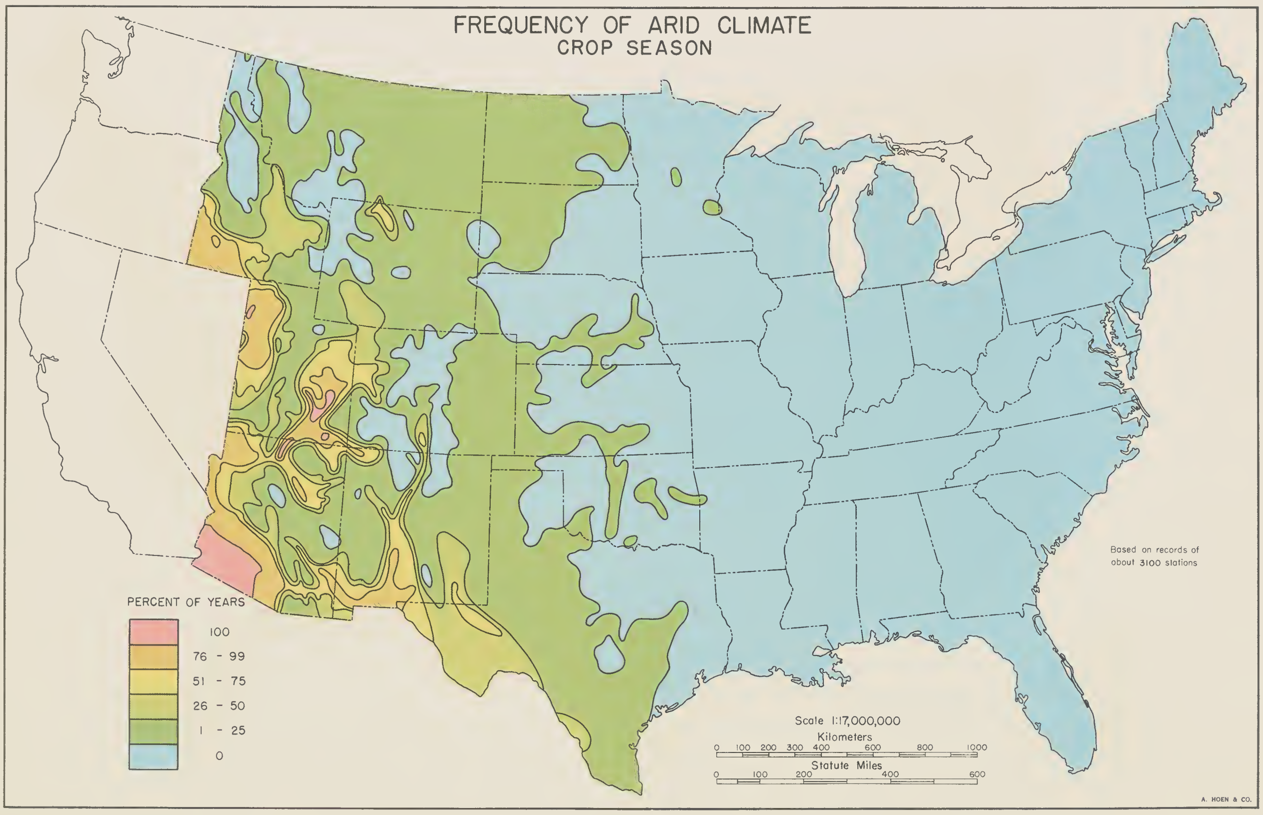


FREQUENCY OF ARID CLIMATE
ANNUAL

Based on records of about 3700 stations

In more than half of the country no year, in the period 1900 to 1939, was arid. In only small areas were all years arid. The areas shown as having arid climate more than 50 percent of the time correspond approximately with those classed as arid on plate 3. In terms of frequency of arid climate in the Great Plains, southeastern Colorado stands out as an area of especially great hazard, and northwestern Nebraska, southwestern South Dakota, and eastern Wyoming as an area in which the hazard is less than the normal for the region.

Plate 86



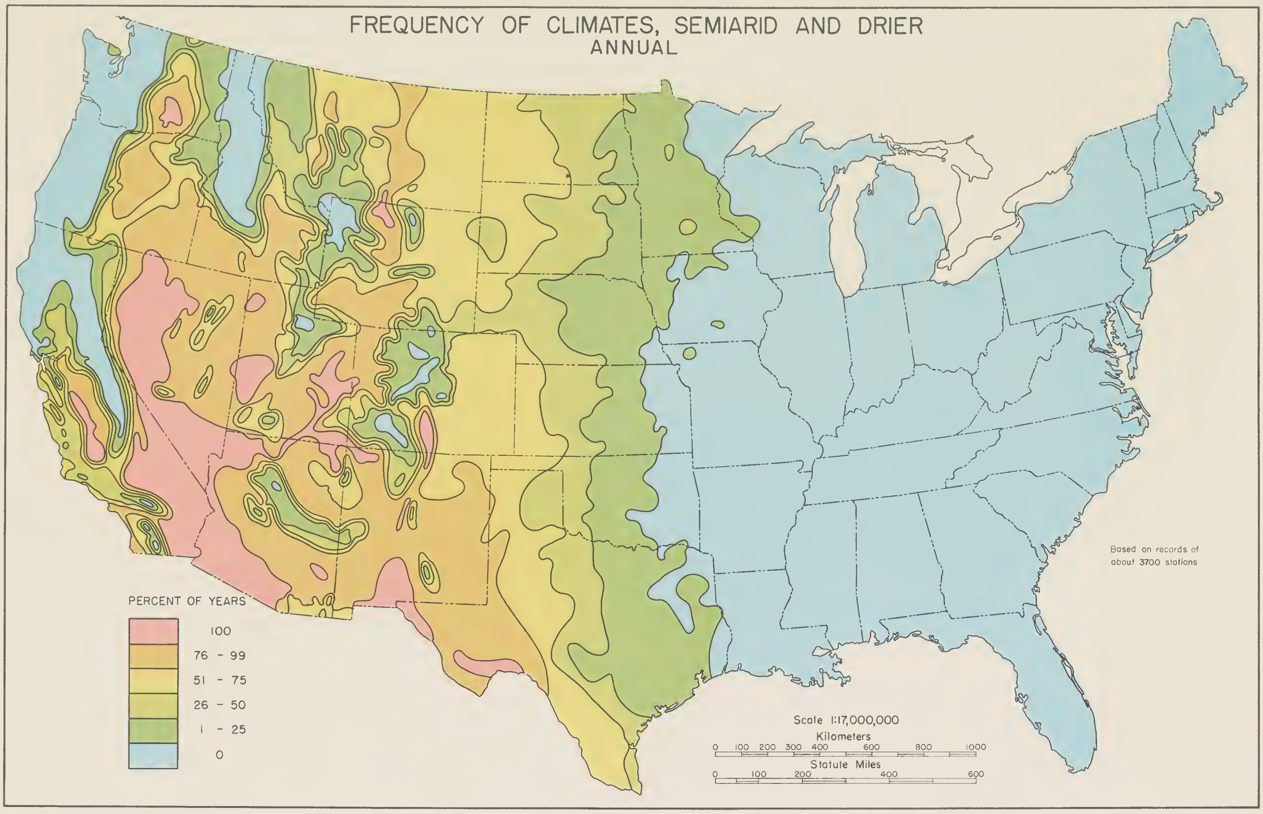
FREQUENCY OF ARID CLIMATE
CROP SEASON

Based on records of about 3100 stations

A. HOEN & CO.

Frequencies of arid climate in the crop season are about the same as for the entire year. The boundary of the region in eastern United States not having experienced an arid crop season since 1900 is more irregular than the corresponding boundary on the annual map. Western Nebraska again stands out as a region having a lower hazard than most of the rest of the Great Plains. Areas that experienced arid crop seasons more than 50 percent of the time correspond approximately with those classed as arid on plate 4.

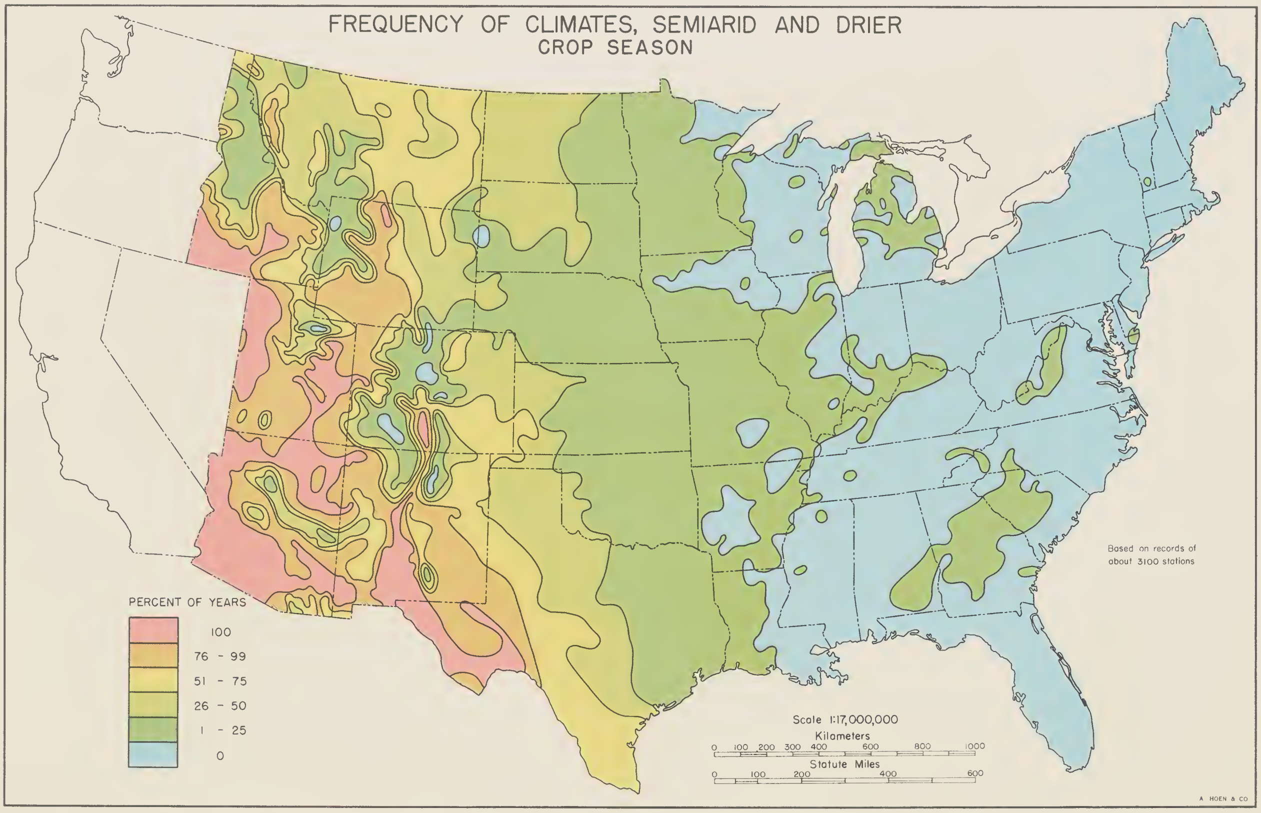
Plate 87



FREQUENCY OF CLIMATES, SEMIARID AND DRIER
ANNUAL

On the whole the parts of the United States that have had no semiarid or arid year since 1900 were confined to the regions of humid and superhumid climate. The moist-subhumid prairie peninsula in Missouri, Iowa, and Illinois also had no semiarid or arid years. The isopleth of 50 percent of years semiarid or drier corresponds approximately with the humid boundary of semiarid climate as shown on plate 3. In western Nebraska and southeastern Wyoming, however, a belt in which semiarid or drier climates occurred less than half of the time extended entirely across the Great Plains to the Rockies. Here, the climatic hazard is lower than elsewhere in the Plains.

Plate 88

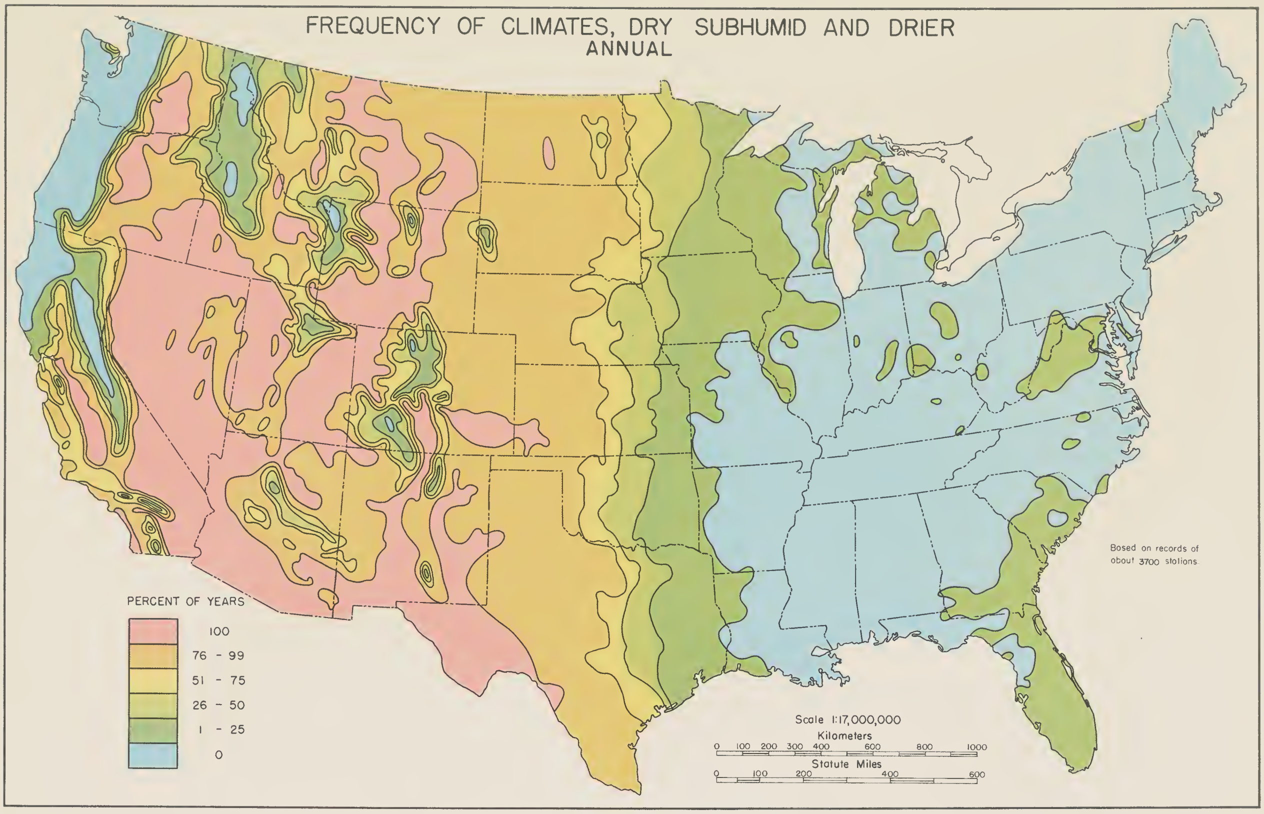


FREQUENCY OF CLIMATES, SEMIARID AND DRIER
CROP SEASON

The area that was never semiarid or arid during the crop season was considerably smaller than the corresponding area for the whole year (plate 87). Semiarid crop seasons have occurred over wide areas in all States east to the Mississippi and to a lesser extent in Illinois, Indiana, Michigan, and in parts of the Southern Piedmont. Western Nebraska again appears as a region in which the climatic hazard is less than elsewhere in the Great Plains.

Plate 89

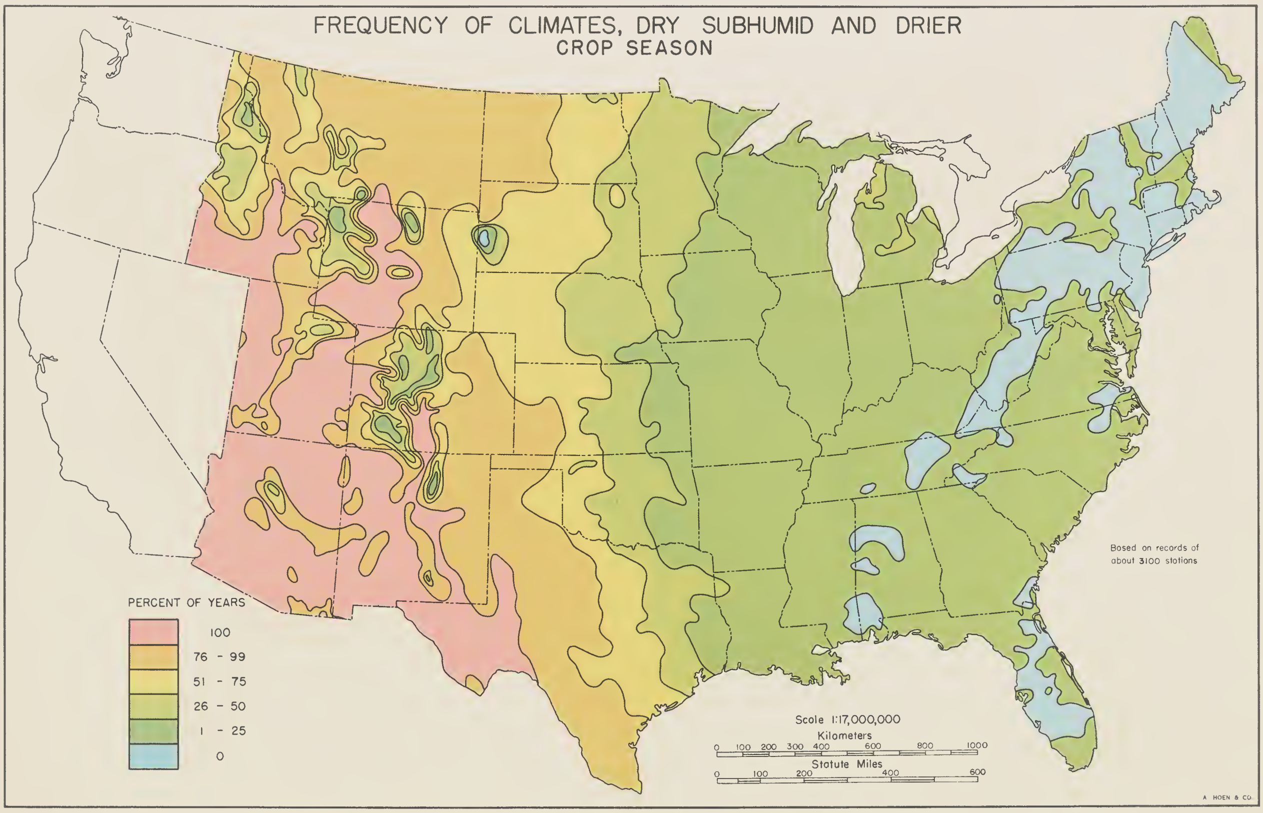
FREQUENCY OF CLIMATES, DRY SUBHUMID AND DRIER
ANNUAL



The area in which no year since 1900 was dry subhumid or drier is entirely within the humid and superhumid regions. Certain drier parts of the humid region such as the southern Coastal Plain, east Texas, eastern Oklahoma and Michigan have had dry-subhumid years, however. The line along which 50 percent of the years were dry subhumid or drier corresponds approximately with that separating dry subhumid from moist subhumid in plate 3. The belt through the middle of the country in which more than 25 percent and less than 75 percent of the years were dry subhumid or drier is narrow. Throughout the Great Plains more than 75 percent of the years were dry subhumid or drier. In a number of areas in the Great Plains, including much of Montana and Wyoming, a central area on the North Dakota and South Dakota border, an area in southeastern Colorado and southwestern Kansas, and most of eastern New Mexico, these climates occurred every year. These are areas of higher than average hazard for the Great Plains.

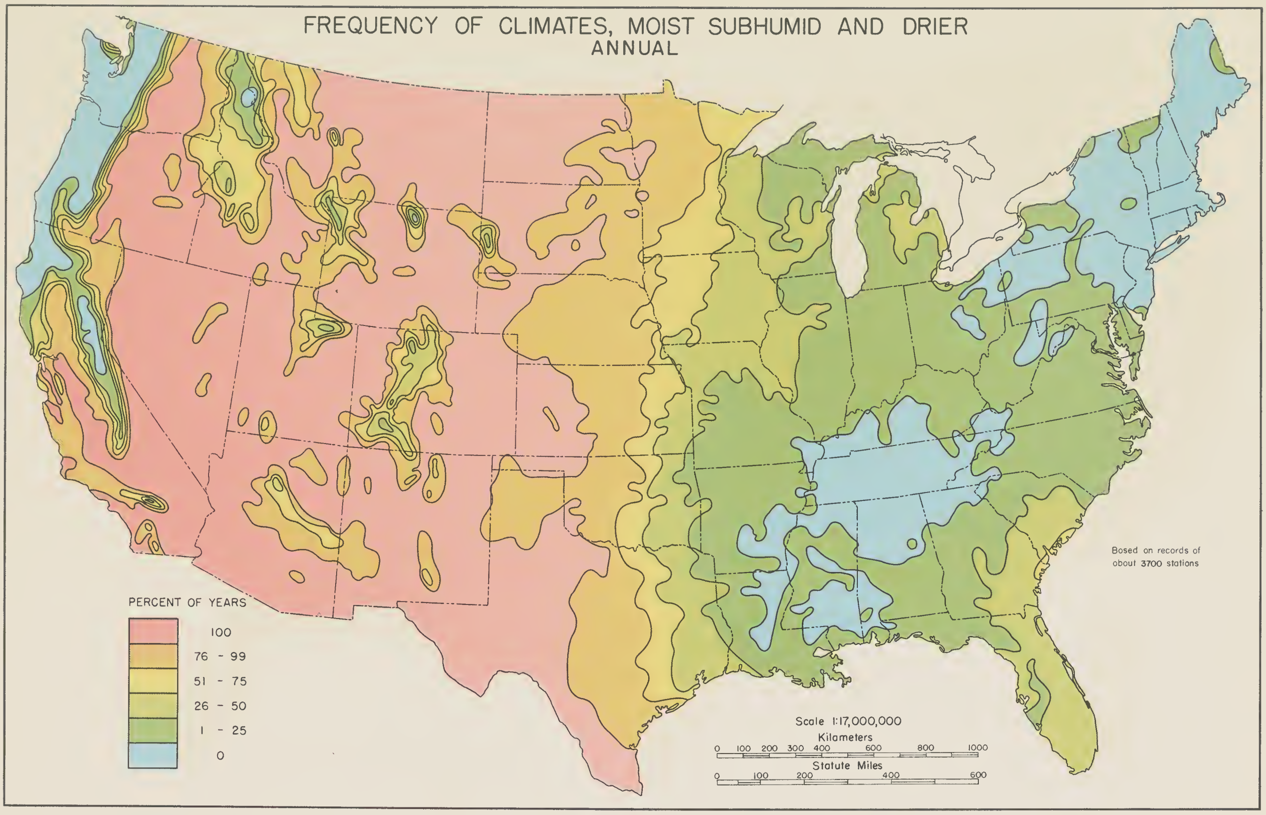
Plate 90

FREQUENCY OF CLIMATES, DRY SUBHUMID AND DRIER
CROP SEASON



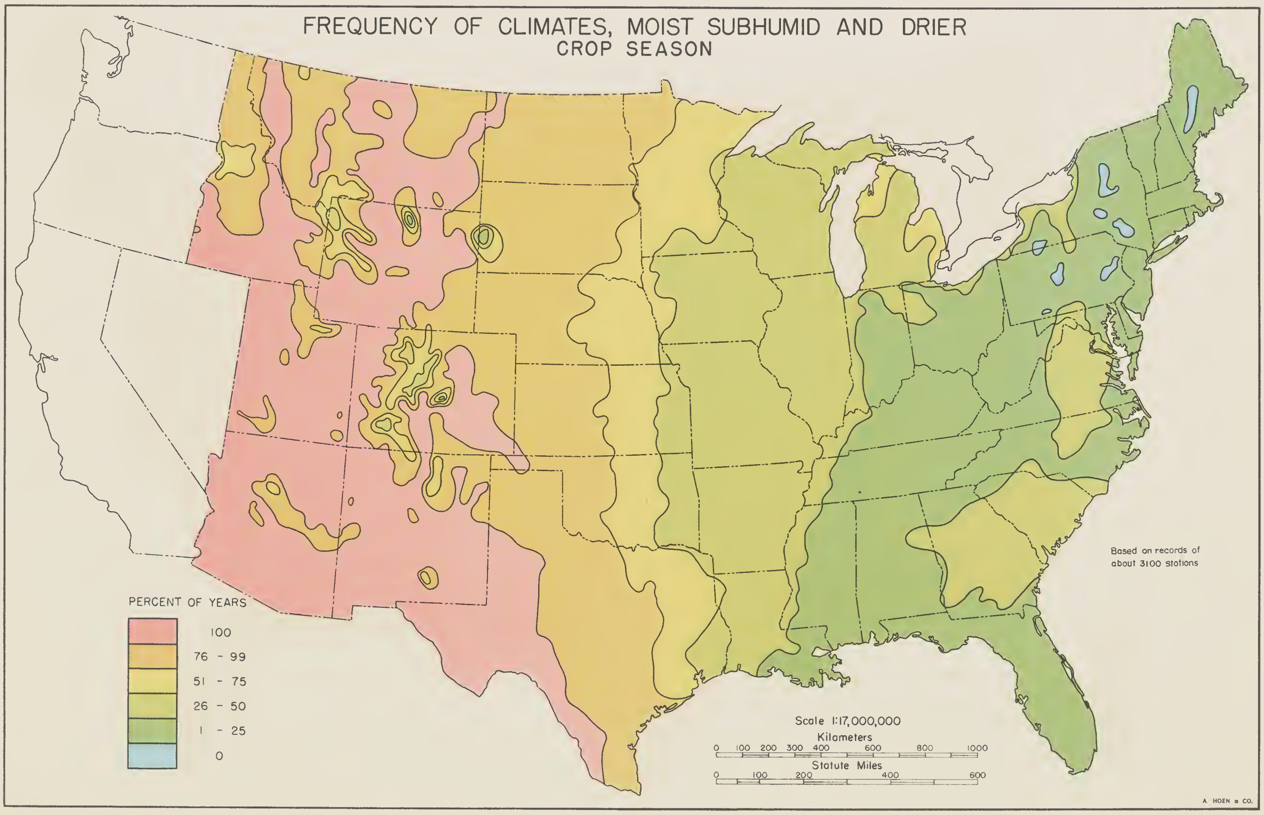
Relatively small are the areas in which no crop season since 1900 was dry subhumid or drier. They extend from New England along the Appalachian axis to Alabama, and include areas in Florida and tidewater Virginia. Nearly half of the country, however, was dry subhumid or drier less than 25 percent of the time. In the Great Plains, western Nebraska and parts of the adjoining States again stand out as a region of reduced hazard, since these climates have occurred less than 75 percent of the time, whereas elsewhere in the Great Plains they have occurred more than 75 percent of the time.

Plate 91



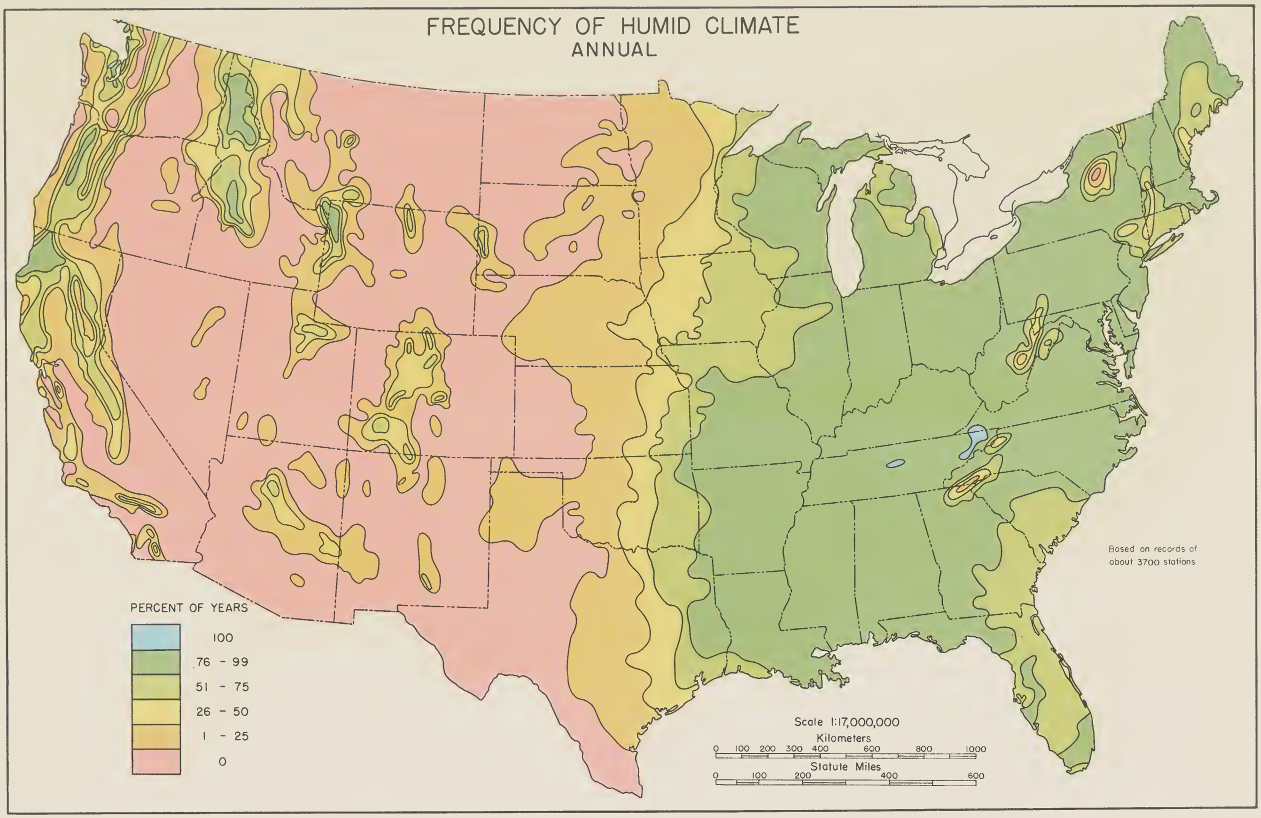
The regions in which the climate since 1900 was never moist subhumid or drier are relatively small. In the eastern part of the country they extend southwestward along the Appalachians from New England into Mississippi and Louisiana. Along the Pacific coast they extend from Washington into northern California. Only a few small islands are present in the Northern Rockies. A small area along the coast of South Carolina and Georgia was moist subhumid or drier more than half of the time. Most of the area west of the 100th meridian was moist subhumid or drier every year.

Plate 92



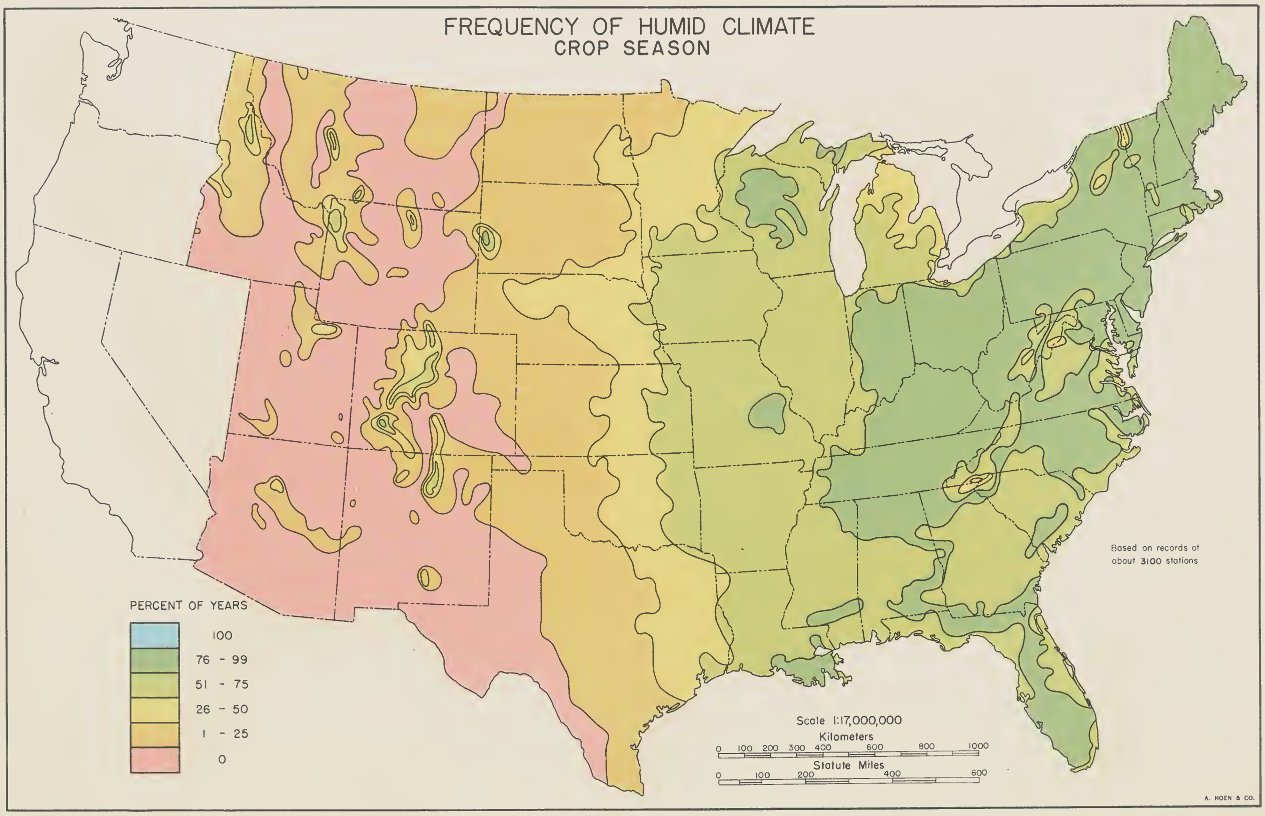
Only in small, scattered islands in the Northeast were there no crop seasons since 1900 moist subhumid or drier, and in only a part of the region east of the Mississippi were these climates present less than 25 percent of the years. In two areas in Michigan they occurred more than 50 percent of the time.

Plate 93



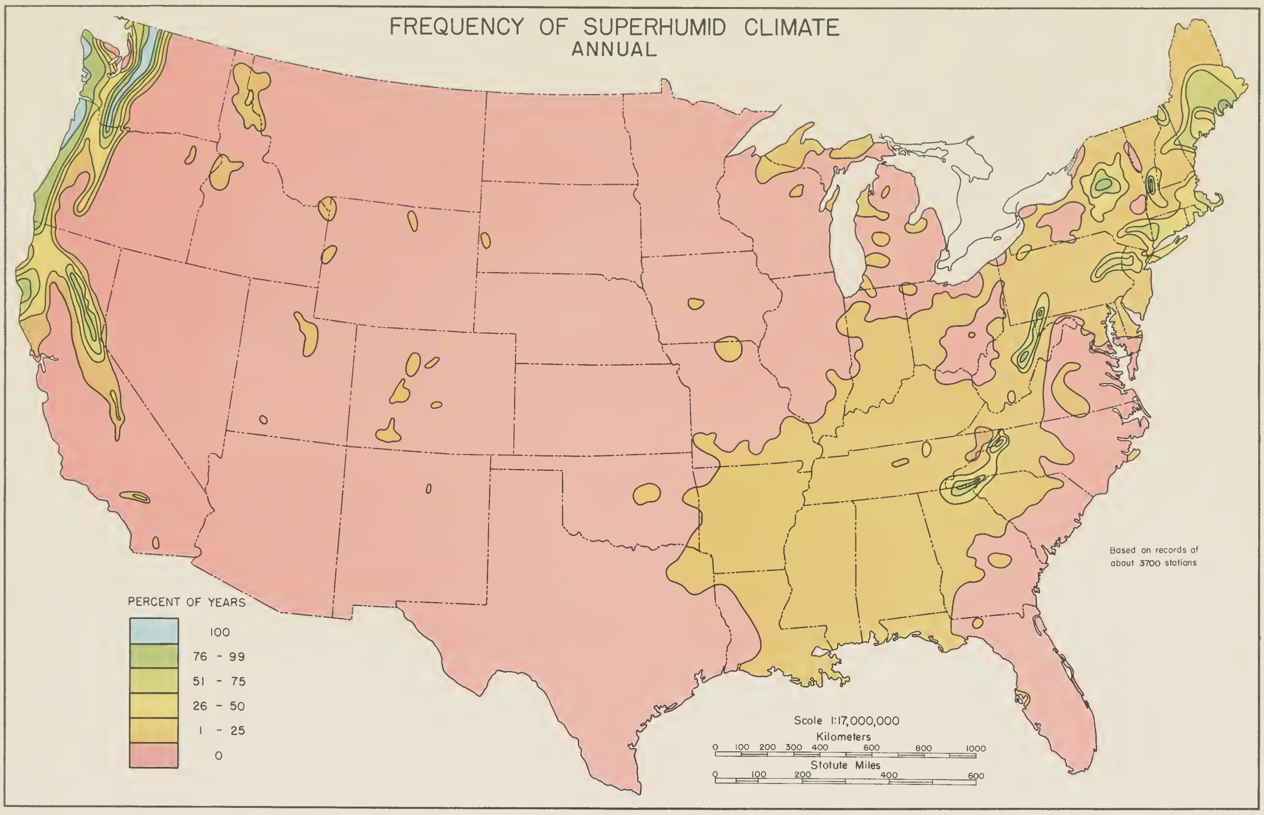
Since this map shows the frequency of humid climate alone, the frequencies are diminished by superhumid years as well as by years that were subhumid or drier. Thus, along the Pacific coast in Washington and Oregon are areas in which no year since 1900 was humid, for the reason that all were superhumid. Only in two small areas, in Tennessee and on the Tennessee-Virginia border, were all years humid. In nearly half of the country there were no humid years.

Plate 94



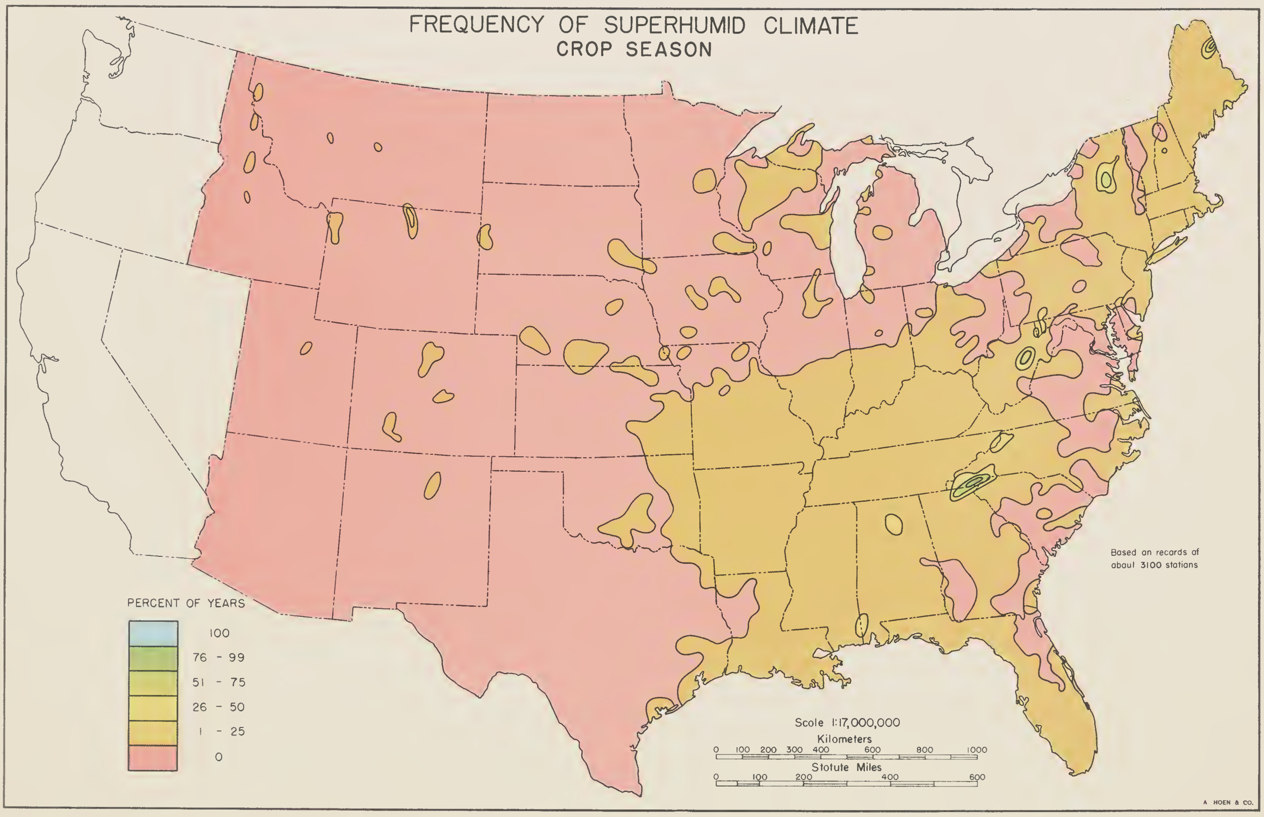
Nowhere was every crop season since 1900 humid, and in only a part of the region east of the Mississippi were more than 75 percent of the crop seasons humid. In part of Michigan, less than half were humid. In the Great Plains of Montana, southeastern Colorado, and south Texas no crop season was humid.

Plate 95



By far the greater part of the United States never had a superhumid year in the period 1900 to 1939. The areas in which more than half of the years were superhumid correspond approximately with the areas of superhumid climate as shown on plate 3. Areas in which every year was superhumid are very few and small and are limited to Washington and Oregon.

Plate 96



Superhumid climate has occurred more widely during the crop season than during the year. There are a number of small scattered areas in the northern prairie States and the central Great Plains that had superhumid climate in at least one crop season since 1900. Eastern Oklahoma, eastern Kansas, central Missouri, and southern Illinois also had superhumid climate in at least one crop season. In the southern Coastal Plains the area in which superhumid climate never occurred is more irregular for the crop season than for the year.